

Investigating Culturally Responsive Mathematics Education

**Cynthia Nicol, Jo-ann Archibald, Jeff Baker
University of British Columbia**

March 2010

This work was funded by a contribution from the Canadian Council on Learning.

All documents produced by the Canadian Council on Learning (CCL) will be available in both French and English. However, documents produced by external organizations for CCL will be posted on the website only in the language of origin. When a full translation is not available, CCL will ensure that an executive summary is available in the other official language.

The opinions expressed herein are solely those of the authors. The Canadian Council on Learning bears no responsibility for its content.

Executive Summary

This report is part of a larger project exploring the development of culturally responsive education in both urban and rural Aboriginal communities. Our research is aimed at addressing the under representation of Indigenous people in math and science careers (Canadian Council for Learning (CCL), 2007), declining rates of participation in school math and science (Ezeife, 2002), and the fact that despite decades of intervention-based reform “Aboriginal children’s scores are getting worse over time” (p. 6). This report focuses on working with community members and teachers in one rural community in the Pacific Northwest that has a high proportion of Aboriginal students.

In this report we explore how culturally responsive mathematics education may provide a framework for transforming mathematics education for Aboriginal teachers. In considering culturally responsive pedagogy we draw upon literature that provides a context for developing a model of education for diverse groups that incorporates connections to culture and community, respects and is responsive to Indigenous knowledge systems and epistemologies, and is rooted in relationships and places.

This report will focus on one of our research sites that we call Indigenous Peoples of the Lands (IPL)¹. As the project is still underway, this report will also focus on the following overarching question:

How do IPL teachers’ involvement in a participatory action research project influence their understanding about culturally responsive pedagogy in the context of mathematics education?

To aid in the investigation of this question, the following research questions were explored:

- 1) What are IPL teachers’ initial perceptions and experiences of culturally responsive mathematics education?

¹ Indigenous Peoples of the Lands (IPL) is a pseudonym for the community. We will use this pseudonym until we have the opportunity to share this report with members of the community and receive their feedback.

- 2) As IPL teachers participate in the project how do they practice culturally responsive education and what does it mean to them?
- 3) How can participatory action research and Indigenous storywork methodology be potential tools for professional development in the context of mathematics education?

This report is organized into four parts. In Part 1 we review the literature of culturally responsive education in general and explore the question ‘What is culturally responsive education and what is it responding to?’ This is followed by a more specific literature review on culturally responsive education [CRE] in the context of mathematics education. In Part 2 we articulate aspects of Indigenous storywork methodology. Part 3 describes our research methods that include participatory action research and methods of developing relationships. Part 4 presents details of our research findings and implications for research and policy.

We articulate a conception of CRE as a process of transformative learning and a direction for systemic educational change. For us, CRE is an approach to teaching and learning that facilitates critical consciousness, engenders respect for diversity and acknowledges the importance of relationships, while honouring, building on, and drawing from the culture, knowledge, and language of students, teachers, and local community. It is both a means of attending to prominent educational issues, and a pledge to respond to the specific needs of students, their families, and their communities.

We believe this conceptualization of CRE complements calls by Aboriginal educators and scholars for the integration of Indigenous knowledge as a foundational aspect of education with Indigenous learners (e.g., Battiste, 2002, 2008; Castango & Brayboy, 2008; Marker, 2006; Urion, 1999), and concur with Pewewardy and Hammer’s (2003) assertion that CRE for Indigenous students “cannot be approached as a recipe or series of steps that teachers can follow” but instead “relies on the development of certain dispositions toward learners and a holistic approach to curriculum and instruction” (p. 1). Our conceptualization for CRE draws upon Archibald’s (1997, 2008) theoretical framework encompassing Indigenous based principles and values of respect,

responsibility, reverence, reciprocity, wholism², inter-relatedness, and synergy where collective knowing is greater than the sum of individual contributions.

This research examines teachers' developing understandings and use of CRE in one rural community that has a high proportion of Indigenous students. As a community-based participatory action research project the teachers and university-based researchers worked together as a group to conceptualize a vision of CRE and to actualize it within their classroom settings. Project teachers met as a group approximately once every 4 to 6 weeks over a span of about three years to explore the nature of CRE and how it might be actualized in IPL. Data for this report include audio and video records of project meetings, interviews and questionnaires with teachers and community members, and researcher field notes. Teachers were co-investigators and collected data in their classrooms that included video records of lessons, digital images of students working on selected problems, and copies of students' work. They shared these data with the group during our project meetings.

The report highlights details of how participating teachers developed and enacted CRE through collective and individual projects. Collective projects were developed by the group with a common or shared question. Each participating teacher worked on the shared problem within his/her classroom, adapting the problem to fit his/her students and grade level. In addition to the collective projects, teachers also worked on classroom projects that were of specific interest to them, and we refer to these as individual projects. Two collective projects and one individual project are examined in detail and illustrate the ways in which teachers practiced CRE in the context of mathematics teaching and learning. These projects provide descriptive detail and examples of how teachers developed lessons that incorporated students' cultural knowledge, experience and mathematical thinking.

Teachers' understanding of CRE is also explored through examination of their developed model for CRE. This model includes key aspects of: place, action, inquiry, relationship and storywork, and stemmed from teachers' examination of their practice as culturally

² We use wholism and wholistic to describe a way of teaching that includes the education of the human being as an entire whole.

responsive educators. Thus findings indicate that teachers can develop living models of CRE and these can provide a structure for teachers to select, adapt, and prepare culturally responsive lessons. The report also examines teachers' learning from CRE and specifically focuses on how participation in the project provided opportunities for: 1) validating cultural practices; 2) being responsive to students; 3) transforming views of mathematics; 4) transforming views of self and culture; and 5) thinking about CRE as bridging culture and mathematics.

Results indicate that teachers valued opportunities to learn with and from each other throughout the project. Teachers reported their observations of increased student engagement and participation during CRE lessons, particularly from some students who rarely contributed to classroom mathematical discussions. Opportunities to present their understanding of, and work with, CRE to their colleagues at local, provincial and national conferences validated and inspired their ongoing efforts to live CRE. The project provided opportunities for participants to experience research as culturally responsive acts – quite different from previous experiences that were characterized as being disrespectful and painful for some participants. Finally, project teachers began to understand CRE as a way of being. Findings indicate that Aboriginal and non-Aboriginal teachers' perspectives and practices can move toward culturally responsive pedagogy. Teachers, who considered themselves strangers to the culture and values of the community at the beginning of the project, were actively developing and teaching culturally responsive mathematics lessons toward the second year of the project.

A number of important considerations in bringing participatory action research and Indigenous storywork methodology together appear to contribute to the healthy exploration of CRE. These include: structuring the group meetings with questions, activities, and ideas from teachers and community members; encouraging diversity in group composition (eg. across schools and grade levels – elementary and secondary levels – administration and teachers and community members); considering sources of motivation (this work takes time and energy and requires recognition of those involved); and group facilitator(s) who are connected to the schools and community. Participatory action research together with Indigenous storywork methodology effectively combines

theory and practice in respectful and reciprocal ways. Together these methods provide a coherent strategy for exploring, creating and sustaining CRE practices.

This research project contributes to the literature calling for educational practices that are culturally responsive (Castango & Brayboy, 2008). It extends Lipka and colleagues' (2007) work of implementing culturally relevant materials by providing a Canadian perspective on CRE development by teachers. CRE practices have held promise for improving mathematics teaching and learning at the elementary and secondary school levels. Our findings provide much needed examples of how culturally responsive mathematics education can be enacted and lived in a rural context. Teachers and community members working together exploring how to draw upon students' interests, backgrounds, and identities as resources for creating meaningful educational experiences can conceptualize the possibilities of culturally responsive education. Our findings indicate that developing culturally responsive practices requires years of sustained and connected professional development involving opportunities for teachers to question, explore, and examine their teaching in a collaborative and collective space.

Implications of this research include recommendations to increase professional development opportunities for CRE, to consider professional development from an holistic perspective, and to continue efforts to raise the consciousness of and practices that are culturally responsive. The educational significance of our research focuses on how teachers become aware of and responsive to Indigenous ways of knowing, students' culture and experiences, and mathematical thinking to develop their own curriculum and instruction. Such practices challenge the concept of uniformity and neutrality of knowledge creation processes and advocate for a pedagogy of multiple discourses that connects disciplines of mathematics education, teacher education, and Indigenous Knowledges and ways of knowing.

Investigating Culturally Responsive Mathematics Education

The Transformative Education for Aboriginal Math and Science Learning (TEAMS-Learning) research collective at the University of British Columbia is composed of graduate students and faculty members who pursue research partnerships with teachers, parents, Elders, schools, and communities to improve math and science teaching and learning at the K-12 level. Our research is aimed at addressing the under representation of Indigenous people in math and science careers (Canadian Council for Learning (CCL), 2007), declining rates of participation in school math and science (Ezeife, 2002), and the fact that despite decades of intervention-based reform “Aboriginal children’s scores are getting worse over time” (p. 6).

This report is part of a larger project exploring the development of culturally responsive education in both urban and rural Aboriginal communities. Focusing on one rural community we describe our efforts to develop relationships working together as Indigenous and non-Indigenous scholars and educators for culturally responsive consciousness and practices. This report focuses on working with community members and teachers in one rural community in the Pacific Northwest that has a high proportion of Aboriginal students. In this community our focus is the mathematics education.

Attending to improving the teaching of mathematics for Indigenous students is significant. Indigenous students in communities around the world have demonstrated a lack of enthusiasm for the experience of schooling in its conventional form (Battiste, 2002; Cooper, Batura, Warren & Grant, 2006; Ezeife, 2002). Educational systems worldwide have failed Indigenous students. In Canada secondary school graduation rates for Aboriginal students is about one-third, half the rate for non-Aboriginal students (Statistics Canada, 2001). Few Aboriginal students enrol in higher-level mathematics courses, few pursue post-secondary studies that require mathematics, and few are represented in careers that use mathematics. Even more devastating is the structure of doubt educational systems have generated among Aboriginal students. Such instilled self-doubt has led learners to discount their inherent experiences, capacities, and gifts (Battiste, 2002). Although policy makers, educators, and researchers are working to provide all students with a strong mathematics education, these results indicate that many students are not being afforded the mathematics education that will serve them throughout their lifetimes (Royal Commission on Aboriginal Peoples, 1996).

The past decade has seen increased efforts to reconceptualize mathematics as an intellectual right of all students (Davis, 2001; Gates & Vistro-Yo, 2003; Malloy, 2002). Yet as Cajete (1999) notes there are few schools that have integrated Native cultural content into their mathematics instruction in a systematic way. A strength of culturally responsive pedagogy is its attention to students’ culture and experience (Gutstein, Lipman, Hernandez & de los Reyes, 1997) and thus, it may provide a framework for transforming mathematics education for Aboriginal students and their teachers.

In considering culturally responsive pedagogy we draw upon literature that provides a context for developing a model of education for diverse groups that incorporates connections to culture and community, respects and is responsive to Indigenous Knowledge systems and epistemologies, and is rooted in relationships and places. The term culturally responsive education was first introduced in the 1970s, and although not new it has over the past year received increased attention as seen in recent academic publications (Avrill et al 2009; Castango & Brayboy, 2008; Geer, Mukhopadhyay, Powell, & Nelson-Barber, 2009). This report is part of a larger study guided by research questions that focus on culturally responsive approaches to teaching mathematics.

This report will focus on one of our research sites that we call Indigenous Peoples of the Lands (IPL)³. As the project is still underway, this report will also focus on the following overarching question:

How do IPL teachers' involvement in a participatory action research project influence their understanding about culturally responsive pedagogy in the context of mathematics education?

To aid in the investigation of this question, the following research questions are framed:

- 1) What are IPL teachers' initial perceptions and experiences of culturally responsive mathematics education?
- 2) As IPL teachers participate in the project how do they practice culturally responsive education and what does it mean to them?
- 3) How can participatory action research and Indigenous storywork methodology be potential tools for professional development in the context of mathematics education?

This report is organized into four parts. In Part 1 of the report we focus on a review of literature of culturally responsive education in general and explore the question 'What is culturally responsive education and what is it responding to?' This is followed by a more specific literature review on culturally responsive education [CRE] in the context of mathematics education. In Part 2 we articulate aspects of Indigenous storywork methodology. Part 3 describes our research methods that include participatory action research and methods of developing relationships. Part 4 presents details of our research findings and implications for research and policy.

PART 1: Theoretical Considerations

In preparation for this report, the authors engaged in an extensive literature review focused on the questions: What is culturally responsive education? How is it related to multicultural education? What is CRE responding to? How do we understand CRE? What issues arise for CRE enacted with/in Indigenous communities? What does the research on

³ Indigenous Peoples of the Lands (IPL) is a pseudonym for the community. We will use this pseudonym until we have the opportunity to share this report with members of the community and receive their feedback.

CRE with/in Indigenous communities suggest with regard to its effectiveness? and What are the critiques and limitations of CRE? Heeding Dunkin's (1996) guidelines for synthesizing research and using Wideen, Mayer-Smith, and Moon's (1998) review as a guide, we initiated our review process with a broad search of the literature to increase our chances of identifying important articles, and then narrowed our results through various means of selection.

Literature Review Method of Inquiry

We began with a search for terms related to CRE in a number of online databases, including the Education Resources Information Center (ERIC), Web of Science, ISI Web of Knowledge, CBCA complete, Academic Search Complete, Education Index, and Google Scholar. Drawing on Gay's (2000) list of synonyms for culturally responsive, we used "culturally relevant, sensitive, centered, congruent, reflective, mediated, contextualized, synchronized, and responsive" (p.29) as search terms, and also added culturally competent and culture based. Through these searches we obtained a substantial list of nearly three thousand articles.

In order to reduce the number of articles for review to a more manageable size, we searched these results for Aboriginal, First Nations, Native, Inuit, Métis, Indigenous, Indian, education, teaching, learning, curriculum, pedagogy, and assessment, and identified widely read articles by sorting results by times cited when available. We then considered the central importance of Indigenous Knowledges (IK) in culturally responsive education, and added IK to our search terms. Due to the large number of articles that remained (approximately 400), we reviewed article titles and abstracts to limit the search to work originating from Canada, the United States, Australia, and New Zealand. While reading and reviewing articles we located other relevant references that were not found in our search. The authors met two to three times per month, where we discussed and identified foundational papers on CRE that were not directly related to Indigenous education but that provided insight into how CRE has been theorized and applied with minority groups, including those considered relevant. We created a master list with 291 articles that was further narrowed by a selection process based on group members' interests. From that list we read and reviewed 62 articles and books, drawing additional references from them as necessary.

Due to the large size and scope of this review and the role the authors' interests played in selecting articles, we in no way claim to be providing a comprehensive or purely objective analysis of the literature on CRE. Our aim has been to gain a greater degree of familiarity with this broad area of research, and to clarify our understandings of CRE as it informs our research and teaching. The large size of the literature reviewed and the scope of issues we wish to address also required that the resulting report be divided into two sections. In this section, we address the question 'What is culturally responsive education?' and discuss the central importance of Indigenous Knowledges for CRE enacted with/in Indigenous communities.

As indicated by the size of literature generated through our review, responding to this question is not a simple task. While the breadth of possible meanings associated with

CRE problematizes attempts at concise definition, it was also an important factor in our decision to adopt CRE as a descriptor for TEAMS-Learning approaches to education and research. For us, the term CRE underscores the idea that culturally responsive teaching and learning can and do occur outside of institutions of formal education. In fact, according to our understanding of CRE, respectful relationships and experiences with the broader school community are fundamental to CRE practices. Of equal importance, the concept of CRE is inclusive of culturally responsive pedagogy, curriculum, and evaluation, thus providing a multidimensional direction for broader systemic educational change.

Culturally responsive pedagogy constitutes the largest segment of the literature on CRE, and numerous definitions and lists of characteristics of culturally responsive teaching and teachers have been offered (e.g., Gay, 2000, 2002b; Phuntsog, 1999; Villegas, 1988; Villegas & Lucas, 2002a; Wlodkowski & Ginsberg, 1994). While many similarities exist among these contributions, each definition was developed within a unique context that resulted in subtle differences. As will be discussed, the term ‘culturally responsive’ has been used in many ways, and has been applied in response to a diverse array of issues. The large number of definitions in the literature precludes the possibility of reviewing each in relation to their context here. Instead, we approach the question ‘What is CRE?’ by relating it to the field of multicultural education, providing a brief historical overview of CRE’s conceptual and theoretical development, identifying issues to which CRE has been used to respond, discussing conceptualizations of CRE with and in Indigenous communities, and exploring the nature of CRE for mathematics education.

Historical Overview of Culturally Responsive Education

According to data from the Education Resource Information Center (ERIC) and Web of Science online databases, the term ‘culturally responsive’ has steadily increased in use since its introduction to educational literature in the late 1970s (e.g., Cazden & Legget, 1976; Escobedo, 1978). Similar terms, such as culturally relevant, culturally sensitive, and culture-based also first appeared in this period, largely following the onset of accelerated rates of globalization. Pewewardy and Hammer (2003) note that interest in culturally responsive teaching “grew during the late 1980s and early 1990s as a result of rapidly rising diversity” and cite “concern over the lack of success of many ethnic/racial minority students despite years of educational reform” as a primary impetus for this research (p. 2).

Much of this early work was based in ‘cultural difference theory’ (Demmert & Towner, 2003; Phuntsog, 1999), which posits that learning difficulties for minority students result from a cultural mismatch between students’ home culture and the culture of the school. Ladson-Billings (1995a) describes this research as rooted in efforts by anthropologists and sociolinguists to “locate the problem of discontinuity between what students experience at home and what they experience at school in the speech and language interaction of teachers and students” (p. 159). While these studies did produce some favorable results (e.g., The Kamehameha Reading Project (Au, 1979; 1980)), they did not critically situate students’ academic success or failure within a broader context of social and educational inequity (Villegas, 1988).

As Ladson-Billings (1995b) explains, these studies all locate “the source of student failure and subsequent achievement within the nexus of speech and language interaction patterns of the teacher and the students” and suggest “that student ‘success’ is represented in achievement within the current social structures extant in schools” (p. 467).

Consequently, “the goal of education becomes how to ‘fit’ students constructed as ‘other’ by virtue of their race/ethnicity, language, or social class into a hierarchical structure that is defined as a *meritocracy*” (p. 467). These approaches to education do not explicitly challenge educational systems to adapt to the changing cultural milieu beyond piecemeal interventions. In the end, students are still deemed meritorious (or otherwise) by their ability to adapt to and succeed in a system that may be alien to their own perspectives and beliefs.

Bartolomé (1994) proposed an alternative explanation for the success of these ‘cultural difference’ approaches to education; the negotiation of acceptable communication patterns also inadvertently raised issues of power and control in the classroom in terms of whose voice was heard and validated. “Thus these studies, in essence, capture the successful negotiation of power relations, which resulted in higher student academic achievement and increased teacher effectiveness” (p. 183). Ladson-Billings (1995a, 1995b) has also identified the importance of identifying and mediating power relations in her theory of culturally relevant pedagogy. She critically connects ‘microsocial’ issues (e.g., incongruous communication in classrooms) with their ‘macrostructural’ contexts (e.g., structural power inequities, institutionalized racism), and emphasizes the impact of formal education on students’ identities (1995b). Culturally relevant pedagogy “not only addresses student achievement but also helps students to accept and affirm their cultural identity while developing critical perspectives that challenge inequities that schools (and other institutions) perpetuate” (Ladson-Billings, 1995b, p. 469).

Ladson-Billings’ (1995a, 1995b) concern for student cultural integrity and broader social inequities also signals the integration of constructivist and sociocultural theories of learning in more recent work in CRE (e.g., Burns, Keyes & Kusimo, 2005; Gay, 2000; Villegas & Lucas, 2002a, 2002b). As Ladson-Billings (1995a) observed, chances of educational success are improved if students “learn what is most meaningful to them” (p. 160). She describes, for example, engaging with popular rap music to “discuss literal and figurative meanings as well as technical aspects of poetry such as rhyme scheme, alliteration and onomatopoeia” (p. 161). Bartolomé (1994) also advocated this approach, describing teaching as ‘additive’; new information should not replace what the students already know. Ladson-Billings’ acknowledgement of the impact social context has on learning also mirrors sociocultural theories of learning, where teachers aim to “create social contexts within the classroom that promote learning” (Burns, Keyes & Kusimo, 2005, p. 23).

In this section we have examined some theoretical and conceptual underpinnings of CRE’s growth from anthropologists’ and sociologists’ work in cultural difference theory, through Ladson-Billings’ (1995a, 1995b) theory of culturally relevant education, to contemporary articulations of culturally responsive education based on constructivist and sociocultural theories of learning. We will now introduce theories of transformative learning (e.g., Mezirow, 1978, 1997, 2000; O’Sullivan; O’Sullivan & Taylor, 2004) and Smith’s (1997, 2003) Indigenous research methodologies in support of our view of CRE

as a transformative process; facilitating changes to individual perspectives, educational systems, and societies.

As described by the Transformative Learning Centre (2004) at the Ontario Institute for Studies in Education, the overarching aim of transformative learning is to facilitate deep, structural shifts in basic premises of thought, feelings, and actions. The concept of a ‘perspective transformation’ triggered by a ‘disorienting dilemma’ was first developed by Mezirow (1978), who subsequently drew on Kuhn’s (1980) paradigm shift, Freire’s (1970) conscientization, and Habermas’ (1981) theory of communicative action to develop his theory of transformative learning (Kitchenham, 2008; Mezirow, 1978, 1997). For Mezirow (1997), one’s ‘perspective’ can be considered a frame of reference that is composed of “habitual ways of thinking, feeling and acting [that] become articulated in a specific point of view—the constellation of belief, value judgment, attitude, and feeling that shape a particular interpretation” (p. 5-6).

In response to a growing awareness of today’s interconnected humanitarian, ecological, and economic crises, transformative learning has recently been directed toward the development of ecological consciousness and identity (e.g., Cajete, 2004; Sterling, 2001). In Mezirow’s (1978, 1997) terminology, it is hoped that the disorienting dilemmas presented by global crises may trigger the emergence of more ecologically-oriented habits of thinking, points of view, and ultimately, actions. O’Sullivan (1999) has acknowledged the importance of Indigenous Knowledges for this work, noting that Indigenous worldviews “suggest a cosmology very different from our traditional western scientific perspective [and that] there is much to be learned about a proper orientation to the earth community from the traditional wisdoms of the native peoples of the Americas” (p. 67).

Smith (1997; 2003) provides an Indigenous perspective, articulating the interdependence among processes of awareness, resistance, and transformative action. Rather than considering perceptual shifts as causally related to changes in individual action and social change, Smith’s nonlinear Indigenous perspective recognizes that the impetus for transformation can and must come from multiple processes simultaneously. This insight was valuable in shifting our thinking away from educational ‘interventions’ that leave the system otherwise unchanged toward the ‘transformation’ of multiple aspects of the system itself.

The majority of literature on culturally responsive approaches to education addresses a growing concern over the cultured nature of the achievement gap and the increasingly apparent cultural disconnections among teachers, students, and schools. Additionally, CRE has been noted as a response to high rates of special education diagnoses among minority students (Gay, 2000, 2002a; Klinger et al., 2005; Villegas & Lucas, 2002a), and simplistic ‘add on’ (Pewewardy, 1998), ‘one size fits all’ (Reyes, 1992), and cookbook ‘methods as solutions’ (Bartolomé, 1994) approaches to cross-cultural education.

While we acknowledge these as important issues that require attention, we also suggest that CRE is capable of having a much broader impact on educational systems by responding to further issues particular to the students, families, and communities that institutions of formal education are meant to serve. Our explicit identification of social

and educational transformation through meaningful local engagement as a primary goal of CRE is hoped to increase this potential impact. In Indigenous contexts, this may include working toward cultural revitalization (of language, knowledge, customs) and attending to a host of other social and economic issues that arose primarily from more hegemonic, colonial approaches to education (Churchill, 2004). In its broadest sense, CRE may also be viewed as a means of responding to global issues (e.g., the HIV/AIDS pandemic, climate change, biodiversity loss, etc.) which impact us all, and in which we are all complicit.

Culturally Responsive Education with/in Indigenous Communities

There is an abundance of literature on culture-based education for Indigenous learners. An increasing interest in culturally responsive approaches is evidenced by the recent publication of an extensive review of culturally responsive schooling for Indigenous youth (Castango & Brayboy, 2008) and a special issue on CRE for American Indian, Alaska Native, and Native Hawaiian students in the *Journal of American Indian Education* (Aguilera et al., 2007). As Castango and Brayboy (2008) note, the centrality of culture in formal education with Indigenous people is “not a new phenomenon or a passing fad; instead, it has been central to tribal nations’ calls for improved schooling since at least the early part of the 20th century” (p. 944).

One of the earliest documented calls for culturally-based education with Indigenous students is contained in the *Merriam Report* (1928) (Demmert & Towner, 2003), which critiqued the United States interaction with and policy regarding Indigenous nations and highlighted Indigenous education as “one of the most deficient areas with the most negative consequences for tribal communities” (Castango & Brayboy, 2008, p. 945). The *Merriam Report* recommended the hiring of more Indigenous teachers, the formation of early childhood programs, and the incorporation of Indigenous languages and cultures in educational material and programming. Despite this early recognition of the centrality of culture to education, little change was enacted in Indigenous peoples’ education for nearly thirty years (Castango & Brayboy, 2008).

Despite an increased awareness of minority student groups and the challenges to their achievement posed by the cultural mismatch factor, African-American and Hispanic students, constituting the largest minority groups in American public schools, have garnered most of the attention of both academic researchers and school-based pedagogical reforms (Ogbu 1987; Phuntsog, 1999, p. 97). In spite of their unique political status and knowledges derived from long-term experience with place, Indigenous people seem to have been marginalized even within minority educational discourse and practice. Some of the earliest studies with Indigenous learners found in our review include Erickson and Mohatt’s (1982) research on cultural organization in classrooms, Philips’ (1983) research on communication patterns, and Chisholm et al.’s (1991) development of culturally relevant materials. While each of these efforts contributed toward the improvement of formal education for Indigenous learners, none meet our criteria of responsiveness to local knowledge and issues.

Recommendations in the early policy paper, *Indian Control of Indian Education* (1972) more closely resemble CRE in their emphasis on parental responsibility and local control

as crucial for improving academic success among Indigenous learners (Kirkness, 1998). The importance of local control is also emphasized in the *Royal Commission on Aboriginal Peoples* (RCAP) (1996), which states that, “the ability to implement culture-based curriculum goes hand in hand with the authority to control what happens in the school system” (p. 478). Although issues of self-determination are rarely invoked in the CRE literature (Castango & Brayboy, 2008), we share Marker’s (2006) optimism that CRE constitutes one means through which “indigenous people are extending their self-determination movements into the educational context where their epistemologies detonate the multicultural folk festival” (Marker, 2006, p. 21).

Culturally responsive pedagogy is conceptualized by the Assembly of Alaska Native Educators “to provide a way for schools and communities to examine the extent to which they are attending to the educational and cultural well being of the students in their care” (Assembly of Alaska Native Educators, 1998, p. 2). In association with the Alaska Rural Systemic Initiative⁴, Alaska Native educators articulated a set of culturally responsive standards with the underlying belief that a focus on local environment, language and culture can support culturally-healthy students, educators, schools, and communities. Culturally responsive pedagogy involves strategies that include an

in-depth study of the surrounding physical and cultural environment in which the school is situated, while recognizing the unique contribution that indigenous people can make to such study as long-term inhabitants who have accumulated extensive specialized knowledge related to that environment (Assembly of Alaska Native Educators, 1998, p. 3).

The Alaska Rural Systemic Initiative activities involve supporting the connectedness between formal educational systems in rural Alaskan Native communities and Indigenous Knowledge systems. A major initiative of the Alaska Rural Systemic Initiative includes developing culturally responsive curriculum and pedagogy that makes cultural knowledge, language, and values a prominent part of the formal curriculum in rural Alaskan communities. Working with a network of 176 rural schools in 20 school districts that serve predominantly Alaska Native students, the Initiative is striving to reconceptualize the relationship of traditional Native knowledge systems and formal schooling knowledge systems. Documenting the activities and knowledge systems of local communities provides situated cultural knowledge that can be integrated in the curriculum and pedagogy of schools in a way that emphasizes connectivity and complementarity. Barnhardt and Kawagley (2005) report that over the past 10 years the initiatives of the Alaska Rural Systemic Initiative “have served to strengthen the quality of educational experiences and consistently improve the academic performance of students in participating schools throughout rural Alaska” (p. 15). The Initiative is in the process of collecting and reporting empirical and descriptive data to examine these claims. However they report that contextual learning that seeks to integrate local context

⁴ The Alaska Rural Systemic Initiative is an educational project begun in 1995 that involves the University of Alaska Fairbanks, the Alaska Federation of Natives, and funding from the National Science Foundation.

and knowledge into curriculum and pedagogy show promise (cf Lipka, Sharp, Adams, & Sharp, 2006).

Culturally Responsive Mathematics Education

Culturally responsive pedagogy then brings significance to learning in local cultural contexts and uses this context as a way of connecting students, with ideas and knowledge systems, and with community practices. Barnhardt and Kawagley (2005) emphasize how the teaching methods of mainstream schooling have not recognized or appreciated Indigenous Knowledge systems that focus on relationships and the importance of inter-relationships and interconnectivity. The work of the Alaska Rural Systemic Initiative challenges a monocultural education system to include and respect knowledge systems and pedagogical practices from cultural traditions other than what has become accepted as formal schooling. For mathematics education this means elucidating the interconnectedness of mathematics within local, regional, national, and global contexts toward acknowledging Indigenous epistemologies in making mathematics meaningful to, for, and with students and communities.

There are various approaches to exploring culture and mathematics. D'Ambrosio (1999), a Brazilian mathematics educator, coined the term ethnomathematics as the intersection of cultural anthropology and history of mathematics. He offers a reconceptualization of mathematics education that addresses the negative self-esteem that is, notes D'Ambrosio particularly strong among minority students of mathematics. Ethnomathematics recognizes that all cultural productions have mathematical elements. Teaching through cultural production thus has the potential to connect students to their own cultural heritage alongside a conception of mathematics as a component of a democratic and just society. Gerdes (1988) demonstrated connections between culture and mathematics in his work that explored the geometrical constructions developed in various traditional Mozambique activities. Other pedagogical approaches have been developed with particular concern for social justice and equity (Gutstein, 2006; Knijnik, 1997). Knijnik (1993) argues that research into the mathematical practices of various groups, particularly subordinated or non-dominant groups works to help those involved recognize that "they do have knowledge ... are capable of acquiring academic knowledge, and ... are capable of establishing comparisons between these two different types of knowledge in order to choose the more suitable when they have real problems to solve (p. 24). Still others such as Lipka, Sharp, Adams, and Sharp (2007) have "translated" mathematical concepts unpacked from local cultural activities to be used in school mathematics. These approaches, although different, address Bishop's (1988) critique that mathematics and mathematics teaching are hegemonic discourses that can distance and exclude students from non-western backgrounds or heritages.

There have been many calls for curriculum that is more responsive, relevant, and connected to students' lives, community and culture (Cajete, 1994; Gay, 2000; Ladson-Billings 1995a, 1995b; Nelson-Barber & Estrin, 1995). In addition there are multiple calls for the inclusion of culturally responsive teaching practices (Gay, 2000; Nelson-Barber & Estrin, 1995, Phuntsog, 1999; Villegas & Lucas, 2002a, 2002b). Demmert and Towner (2003) in their review of the literature on culturally responsive teaching report

that there is little evidence that indicates a relationship between achievement and culturally responsive practices. More recently studies by Lipka and colleagues (2007) provide some evidence to indicate that culturally responsive curriculum and pedagogy can improve both Native and non-Native students' mathematics achievement.

Certainly improving student learning, participation and achievement are goals of culturally responsive curriculum and pedagogy. However, Averill, Anderson, Easton, Te Maro, Smith and Hynds (2009), in their development of models for culturally responsive teaching note "raising the social consciousness and developing cultural competence are also key goals of culturally responsive teaching" (p. 160) and should be considered a significant aspect of research on culturally responsive education. Yet, how non-Indigenous teachers develop cultural understandings (Dion, 2009) and how Indigenous educators may enact culturally appropriate teaching (Yazzie-Mintz, 2007) is still not well understood. Raising the social consciousness of educators, decolonizing teacher education, developing partnerships between non-Aboriginal and Aboriginal educators (Averill et al., 2009) and working with educators to recognize the funds of knowledge (Civil & Beriner, 2006) and cultural resources that students and teachers bring with them to the classroom is significant work. However, few models of such work exist.

Indigenous Epistemologies and Cultural Worldviews

Kuokkanen (2007) refers to Indigenous epistemologies as both personal and collective experiences, "systems of knowledge rooted in experiences and practices that have accumulated over generations" (p. xviii). There are multiple sources of Indigenous epistemologies or ways of knowing that are valued in Indigenous societies. Brant Castellano (2000) offers three sources that are neither discrete nor individualistic but instead holistic and collective. These sources, of course, vary from nation to nation, but as Kuokkanen (2007) notes, Indigenous peoples around the world share a set of experiences framed by an intimate connection to the land and injustices of colonization by the dominant society. One source is traditional knowledge; knowledge that is passed down by generations through language, oral traditions and ceremony. Traditional knowledge preserves knowledge of genealogies, land use, ancestral beliefs and values. A second source is empirical knowledge; that gained through observation but not necessarily, Brant Castellano (2000) states, through quantification of repeated observations in controlled environments. Instead empirical knowledge involves the collection of views from different perspectives over time. Revealed knowledge is a third source. It is more spiritual in nature and accessed through dreams, visions, and intuitions.

As with other ways of knowing, there are multiple characteristics of Indigenous epistemologies. Archibald (2008) describes Indigenous Knowledges as being experiential, storied, relational, contextual and wholistic. Experiences with the land and nature emphasize the value of and connection of the inner passion, feel, and heart with the environment. Archibald's concept of Indigenous storywork points to the importance of oral language, narrative and story that convey Aboriginal values, pedagogies, information and histories. It points to the importance of holistic frames of reference rather than fragmented ones, the interconnections and relationships of humans and non-humans

to the natural and physical world (Barnhardt and Kawagley, 2005), and it foregrounds intergenerational accumulation and communication of knowledge.

The term Indigenous epistemologies is not meant to describe a way of seeing or being for all Indigenous peoples. Indigenous epistemology is itself diverse. It is instead a concept that describes tendencies of traditional Indigenous ways of seeing and being in the world rather than fixed traits that reside in individuals. Quoting Bielawski (1990), Barnhardt and Kawagley (2005) highlight the point that “Indigenous knowledge is not static; an unchanging artifact of a former lifeway. It has been adapting to the contemporary world since contact with ‘others’ began, and it will continue to change” (p. 12). Thus, Indigenous epistemologies imply a way of knowing that is adaptive, complex, and growing in nonlinear dynamic ways. The challenge, note Barnhardt and Kawagley, is to move Indigenous Knowledge systems and worldviews from the margin of formal schooling to mainstream schooling and to consider how Indigenous Knowledge systems can inform and be informed by other ways of seeing the world. A focus on Indigenous Knowledge systems places value and importance on knowledge developed and distributed with and by local cultures and communities. The challenge is how to include and honour local cultures, places, and traditions in a system of schooling that has over time, with colonization, done so much damage to culture, places, and the value of other world views. We ask along with Kuokkanen (2007) how Indigenous epistemologies might be sources of inspiration and intellectual or theoretical tools for challenging mainstream curriculum and pedagogy.

PART 2: Developing a Culturally Responsive Mathematics Education Framework

We articulate a conception of CRE as a process of transformative learning and a direction for systemic educational change. For us, CRE is an approach to teaching and learning that facilitates critical consciousness, engenders respect for diversity and acknowledges the importance of relationships, while honouring, building on, and drawing from the culture, knowledge, and language of students, teachers, and local community. It is both a means of attending to prominent educational issues, and a pledge to respond to the specific needs of students, their families, and their communities.

We believe this conceptualization of CRE complements calls by Aboriginal educators and scholars for the integration of Indigenous Knowledges as a foundational aspect of education with Indigenous learners (e.g., Battiste, 2002, 2008; Castango & Brayboy, 2008; Marker, 2006; Urion, 1999), and concur with Pewewardy and Hammer’s (2003) assertion that CRE for Indigenous students “cannot be approached as a recipe or series of steps that teachers can follow” but instead “relies on the development of certain dispositions toward learners and a holistic approach to curriculum and instruction” (p. 1).

We draw upon Archibald’s (1997, 2008) theoretical framework encompassing Indigenous based principles/values of respect, responsibility, reverence, reciprocity, wholism⁵, inter-relatedness, and synergy. Archibald’s framework builds upon the 4Rs of respect,

⁵ We use wholism and wholistic to describe a way of teaching that includes the education of the human being as an entire whole.

responsibility, relevance, and reciprocity first articulated by Verna J. Kirkness and Ray Barnhardt (1991) in reference to making higher education more successful for Indigenous learners. Kirkness and Barnhardt advocate that the university context needs to have programs and student services that demonstrate respect toward Indigenous learners, that programs are relevant to the needs and cultures of these learners and their communities, that students and university enact their responsibilities to improve Indigenous higher education, and that a reciprocal relationship exists between Indigenous people, their communities, and the university.

In Archibald's methodological framework, the 4Rs of respect, responsibility, reverence, and reciprocity relate to ways of working with people and with Indigenous Knowledges. The remaining principles of wholism, inter-relatedness, and synergy relate to how Indigenous Knowledges and Indigenous stories are used in the research process. The term storywork is coined from a Sto:lo (Coast Salish) cultural way of focusing attention on learning or "working" with stories. In Sto:lo cultural gatherings, a spokesperson tells the people gathered "My dear ones, the work will begin." When we hear these words, we pay attention to what we hear and what we see because the culturally based work is important to individuals, families, communities, and the larger Indigenous nation.

Respect is focused on the cultural knowledge embedded in the stories and for the people who tell their stories. Taking the time necessary to develop respectful research relationships and to learn cultural protocols is an important ethical responsibility. Reverence is a deep respect for the spiritual nature of humans, nature/land, and for this part of Indigenous Knowledges. Prayerful thoughts and words, time spent in nature, engagement in ceremony, stories and songs are some examples of reverential actions. Reciprocity becomes a circular action of receiving knowledge and "giving back" to the people or community with whom one has worked so that Indigenous Knowledges is sustained in ways that are respectful, responsible, reverent, and beneficial to the Indigenous people and their communities.

Indigenous Knowledges and stories often have a wholistic nature where they contribute to human spiritual, emotional, physical, and intellectual development (Archibald, 1997, 2008; Battiste, 2000; Brant Castellano, 2000; Cajete, 1994, 1999; Sarris, 1993; Silko, 1981; & Sioui, 1992). An Indigenous concept of an inclusive wholistic circle places these four components in quadrants as indicated in Figure 1.

Indigenous epistemologies; and 3) school mathematics, everyday mathematics and the discipline of mathematics. A focus on students' emotions drew attention to the power of mathematics to build students' confidence and self-esteem but also to undermine such confidence. This framework along with our Indigenous storywork framework guided our work with teachers and community members to explore and articulate what a culturally responsive pedagogy for mathematics teaching and learning might look like (Figure 2).

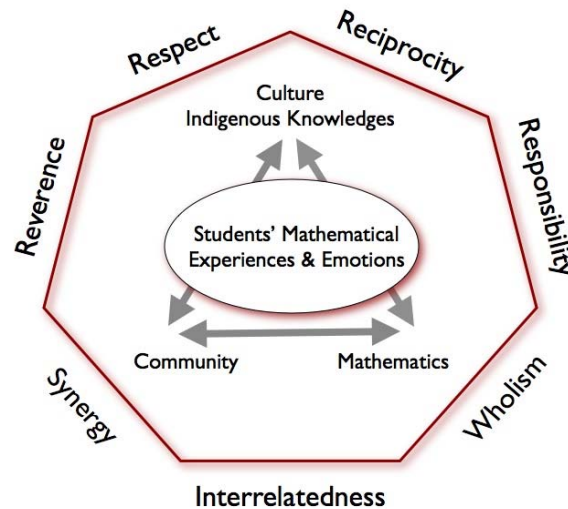


Figure 2: A framework for considering culturally responsive mathematics education with/in Indigenous storywork methodology and pedagogy

Our framework begins with the seven principles of Indigenous storywork that encircled and guided us in considering how to work with community members, students, and teachers to bring into relationship community, mathematics, culture, Indigenous epistemologies and students' mathematical thinking and emotions. Attending to the principles of Indigenous storywork while considering how community, culture and students' thinking can be resources for and sources of knowledge for exploring mathematics we worked toward transforming mathematics education for all students. Our approach is therefore exploratory; imagining possibilities, enacting strategies and documenting activities to critically question a model of teaching and learning mathematics that has focused on students' deficits rather than strengths. Our project is developed with the view to recognizing culture and community as resources for educators, students, parents, community members and administrators.

Participatory Action Research

In addition to Indigenous storywork methodology and pedagogy we drew upon the literature in the field of participatory action research to help frame our work with teachers as they explored culturally responsive curriculum development and practice. There are multiple models for curriculum development. Traditional models of curriculum development failed to engage teachers as key participants or agents of change. The dominant “research, development, and disseminate” (RDD) model of mathematics education (Howson, Keitel, Kilpatrick, 1981) did not necessarily include teachers in curriculum planning or development. In this model teachers were considered as technicians who transmitted or delivered curriculum programs, curriculum goals were then delivered by experts at the ‘centre’ who then oversaw the project development, while the new curriculum was implemented or reproduced by teachers at the ‘periphery’ of the curriculum development. The RDD model provides little autonomy to schools or individual teachers. Instead teachers are mandated or persuaded to adopt particular curricula. Ben-Peretz (1990) argues that these enforcing techniques are tyrannical. They do not recognize the complex understanding and knowledge teachers use to interpret the curriculum potential of materials for their particular students and classroom contexts. Such top-down and centre-to-periphery models of curriculum development are found ineffective (Altricher & Posch, 2009) mainly because they do not consider teachers informed and creative interpretations of curriculum as important for curriculum implementation. These models operate under the assumption that change is a linear process – a linear sequence of events from planning, to designing, to implementing. Curriculum is developed by experts, and then passed on to practitioners, who must implement and transmit the material.

Apple (1993) describes the separation of conception to implementation as having profound consequences, where teachers become ‘deskilled’ as their power and control dissipate and their skills are called upon less and less. Assumptions of curriculum development in this model recognize the teacher as a consumer of curriculum that is sometimes referred to as “teacher-proof” curriculum, appropriate for any teacher, in any school, in any context. Clearly this is problematic. Curriculum that is developed using the centre-to-periphery model questions the professionalism of teaching. Ben-Peretz (1990) highlights the professional right of teachers to make autonomous and independent decisions, free from the external and non-professional controls and constraints. The RDD model fails to recognize the practical, professional knowledge that teachers contribute toward lesson planning and curriculum development (Schon, 1983).

There are a number of strategies developed to involve teachers in curriculum development that include school-based curriculum development, lesson study, and communities of inquiry. What is significant about these approaches is that they attempt to involve teachers in decision-making relating to curriculum development and implementation. Teachers become participants rather than only implementers and curriculum development recognizes that teaching/learning is context dependent and closely tied to teachers’ personal theories of teaching and learning mathematics.

Improving teaching practice does not involve implementing externally developed materials. Instead, improving practice involves consideration and integration of personal and professional knowledge that acknowledge the artistry, connoisseurship, personal theories and practical actions of teachers. As a means of expanding upon and providing opportunities for professional and personal growth, action research holds promise. Action research and “teachers-as-researchers” models bridge the felt gap between research and practice; between educational theory and professional practice. These models encourage teachers to use their classrooms as contexts for research, for exploring and reflecting on their curricular and pedagogical decision-making.

Action research, however, has been criticized as simply another attempt at control. Connelly and Clandinin (1988) argue that action research treats teachers as the means of carrying out others’ ideas. It is suggested that a subtle, asymmetrical power relation occurs, that renders teachers powerless in a supposedly liberating methodology. For example, teachers are asked (required) to attend professional development sessions that involve action research, are asked to field test various materials, or asked to join a particular action research group or community of inquiry as a form of professional development. Teacher action researcher can also be criticized for focusing too heavily on the individual teacher without considering the social network of practice.

Participatory action research addresses some of these concerns and takes this one step further by emphasizing teaching and “research as a form of collective knowledge construction that promotes creativity in the networks of each context” (Gomez, Fernandez, Gomez & Mas, 2009). *Participatory* action research in the context of curriculum development emphasizes the collaborative and participatory nature of curriculum design. Reason and Bradbury (2006) list key features of participatory action research (PAR) as: responding to practical and pressing issues in lives of people; engaging with people in collaborative relationships; drawing on multiple ways of knowing and co-generation of knowledge; seeking to address issues of significance linking knowledge generated to social action concerning flourishing human persons, their communities and the wider ecology; and recognizing PAR as a living, emergent process that deepens the understanding of those involved and their capacities as co-inquires both individually and collectively (p. xxii).

Participatory action research (PAR) shares many of the same characteristics as Indigenous storywork methodology. As with Indigenous storywork, PAR does not prescribe a set of research methods but is instead an approach to doing research that emphasizes an action dimension to knowledge generation that is grounded in addressing real-life problems through building relationships and co-generation of knowledge. They are both methodologies that can critique the historically marginalized position of Indigenous Knowledges, people and communities. Indigenous research methodologies and PAR challenge research practices that locate the ‘problem’ being addressed solely within Indigenous people or communities (Smith, 1999) and emphasize practices of collaborations and relationships. Participatory action research (PAR) and Indigenous storywork methodologies hold promise for meaningful change in mathematics education.

The aim of transforming teacher's assumptions and actions, begins with an examination on their current practice, develops through critical consideration of alternatives and is lived by deciding on and practicing alternative curriculum and pedagogical actions. This then requires teachers' existing ideas be articulated, analyzed, critiqued, compared and contrasted with others. Through PAR and Indigenous storywork methodologies teachers, both Aboriginal and non-Aboriginal, have the opportunity to critically examine their own understanding of the role of culture and community in mathematics education and what this might mean for their own students and classrooms.

Bringing together Indigenous storywork methodology and participatory action research points to the importance of teachers and community members' participation in the research that is of interest and concern to them. It also highlights a way of working with people who share similar concerns and are interested in making things better. It is as a form of research that, as Heron & Reason (2006) describe is research *with* rather than research *on* people.

Acknowledging the interest for and promise of culturally responsive pedagogy and the parallel need for culturally responsive research approaches we ask: How do teachers set out to practice culturally responsive education and how can teacher educators and administrators support teachers interested in being culturally responsive mathematics teachers?

PART 3: Developing Relationships and Modes of Inquiry

Guided by Indigenous storywork methodology and participatory action research our study involves working with students, teachers, parents, and community members, to explore ways of teaching mathematics that are culturally responsive. Establishing and maintaining relationships is a fundamental part of a research process that honours cultural consciousness and connectedness. Thus our research strategy informed and guided by Indigenous storywork methodology and PAR addresses the importance of collective relationship building over the initiation, representation, and legitimacy of the research process. We recognize the community members, teachers and administrators as co-researchers or collaborators in the study. For this report we focus on one of the rural communities in the project located in the coastal region of the pacific northwest—that of Indigenous Peoples of Lands (pseudonym)⁶.

Context, Participants and Relationships

Indigenous Peoples of the Lands (IPL) is a coastal area located in the pacific northwest of British Columbia. The IPL Nation comprises about 40% of the 5,000 people living in the IPL traditional and unceded territory. Two major communities are situated within the land base of two major IPL Bands: one in the northern lands and the other a one and a

⁶ We use a pseudonym for the district as we are in the process of sharing this report with community members. Feedback from the community will determine whether and how pseudonyms for the district and participants are used.

half hour drive away in the southern lands. The one public school district that services the IPL has a total of 722 students of whom 60% (426) are Indigenous, while most of the teachers are non-Indigenous. There is one Indigenous school in the IPL that is not part of the public school district. Most IPL Nation students live in the reserve village in the north and south of the lands. The district is one of the more isolated districts in British Columbia with access to British Columbia's major city only by a two-hour plane trip or by a three-day drive. Isolation and the declining economy in natural resources such as logging and fishing have contributed to the school district's declining student enrolment. However, despite a declining non-Indigenous student population, the Indigenous student population is expected to increase continually in the next few years. Over the past five school years from 2002 to 2007 secondary school graduation rates (Grade 12 graduation within 6 years) ranged from a high of 46% to a low of 28% for Aboriginal students and from a high of 97% to a low of 39% for non-Aboriginal students. The provincial graduation rate for all students is around 80%. The IPL district was concerned about their students' success and performance in mathematics. In 2006-07, the school district data shows that 56% of the IPL students did not meet expectations in grade 4 provincial mathematics assessments compared to 38% of non-IPL students. The grade seven assessments indicate that 53% of the IPL students did not meet grade level expectations compared to 44% of non-IPL students. Over the years the district has focused attention on improving students' performance on provincial assessments of writing and reading, and on working with teachers to understand and appreciate IPL culture and values. Current district goals also include improving student achievement in numeracy.

The school district leaders and community education council voiced their support and approval for the project through a letter from the school district and verbal agreement at a council meeting attended by the researchers. The district was interested in not only addressing students' participation and achievement in mathematics but also in developing increased communication between the elementary and secondary schools as well as within the district schools. Thus it was decided that teachers at both the elementary and secondary levels would be invited to participate.

Our community-oriented research project emphasizes developing relationships with Elders, community members and teachers. The IPL education director arranged for us to meet with two Elders' groups from the two communities. At these sessions we explained the study and had engaging discussions about how they had used math in their everyday living while growing up and earning a living. Some at first did not think that they had used math in their daily lives, but as the discussion began, and members shared their ways of using math, those who doubted the use of math began to recount their experiences that included aspects of math. They were enthused about the study because they had a positive attitude and experience about math. To them, they used math for a reason. Many of their stories centered on the numerical characteristics of math, and other concepts were illustrated such as proportion, estimating, and problem-solving. Over the course of the project we have had multiple meetings and conversations with community Elders, community artists, Indigenous Knowledge holders, the IPL Education Council, the school district, and teachers. We have asked about and listened to community member's desires, hopes, problems, and possibilities for mathematics teaching and

learning as well as strategies to build upon Indigenous cultural knowledge, place-based knowing, and community resources.

Since 2006, two very supportive school district Aboriginal education directors/principals⁷ have provided valuable help to the study. The first director facilitated discussions with the community Indigenous education council to gain their approval for conducting this study on their lands and with their communities, provided communications liaison with school district teachers, and facilitated two Elders meetings held in both the communities. The second school district principal participates in the teachers' discussion sessions and continues to provide school district liaison and support.

The primary participants for this report are 5 teachers, the IPL district principal of Aboriginal education, and one community member who is a curator of the local museum. Four of the five teachers have participated in the project for three school years, with one teacher recently joining the group in 2007. Teachers were invited to participate by the district's Director of Aboriginal Education who sent e-mail invitations to administrators and teachers in the 6 district schools (2 high schools and 4 elementary schools that consist of 50 full time equivalent teachers and 50 full time equivalent support workers). All teachers who were interested in working with the district, the community and the university to explore culturally responsive ways of teaching mathematics were included in the project. Three of the 7 participants are of First Nations ancestry: Jess, the district principal of Aboriginal education, Darren⁸ an elementary teacher, and Kuat the museum curator. Carol, Miki, and Maria are elementary teachers and Kit is a high school mathematics and science teacher, each is of non-Aboriginal ancestry.

Table 1
Overview of Participant Teaching Experience

Participant (pseudonyms)	Grade Levels Taught	Teaching Experience (years)	Teaching in Indigenous Lands of the Peoples District (years)
Jess	Elementary & Principal	14	14
Carol	Elementary & Secondary	14	11
Darren	Elementary	13	13
Kit	Secondary	7	7
Miki	Elementary & Secondary Math	4	4
Maria	Elementary & Secondary Math	4	2
Kuat	Museum educator/school resource worker	2	2

Participation in the project involved attending full-day group meetings about every 4 to 8 weeks throughout the school year. The long time frame was important as it allowed the

⁷ The title changed from district director to district principal.

⁸ All names are pseudonyms.

participants and the researchers the necessary time to reflect on theories, practices, beliefs and actions in our effort to improve practice and document change. It also provided the group time to develop needed relationships that could ensure participants felt comfortable sharing their ideas, as well as set long term goals, develop CRE curriculum, implement ideas and materials developed, reflect on what happened and modify knowledge and practice, where necessary.

Some university-based researchers and graduate students traveled to attend these meetings, the principal investigator of the project, attended all meetings as did most of the teacher participants. In order to foreground and emphasize the principles of Indigenous epistemologies and Indigenous storywork as a theoretical framework for culturally responsive mathematics education our meetings were rarely hosted within a school or institutional building. Instead we met at local cultural centres, longhouses, the museum and local café. These were places that took us closer to IPL cultural values and knowledges and were located within the IPL reserve villages. Community members often attended these meetings as guests and participants. Field trips took us to local artists who invited us to their carving sheds. The place of our meetings was important and inspired us to explore an open-ness toward connecting mathematics, Indigenous ways of knowing, students' thinking and emotions and community.

In summary, the group hoped to:

- 1) provide systematic and continuous opportunities (through participatory action research and Indigenous research methodologies) for teachers to examine their own theories and practices of CRE in the context of their mathematics teaching
- 2) provide opportunities for teachers to engage in CRE curriculum design and professional development to transform mathematics education for all their students
- 3) learn about the ways they (teachers) can be involved in and practice participatory action research and storywork methodology in a CRE context within IPL
- 4) describe the effectiveness of a particular kind of practice (participatory action research and Indigenous storywork methodology) in CRE education and curriculum development.

The interests and questions of those attending and the interests and needs of the community determined the focus of the meetings. Some meetings were focused on collectively solving mathematics problems that might inspire and engage students. Other meetings focused on learning more about IPL Indigenous ways of knowing. Still others focused on learning more about the changes to the revised school mathematics curriculum. Some meeting topics included:

- 1) exploring students' mathematical thinking to learn more about students' strengths and interests;
- 2) understanding student emotions and cultural backgrounds that could help teachers develop mathematics lessons that are emotionally engaging for students;
- 3) investigating map-making and IPL oral stories to examine the interrelatedness of mathematics education and cultural, social, political, and historical issues;

- 4) exploring digital images of IPL to inspire mathematical problem solving in the culture and community; and
- 5) exploring the process of canoe building, weaving and carving and the mathematics involved in these through collaboration with museum curators, Elders and community artists .

The university team organized the meetings guided by the interests of teachers and community participants. This was not always a smooth process. Some district administration suggested the group focus on student assessment through implementing district wide examinations in both the elementary and secondary levels and by implementing common mathematics textbooks. The project teachers, however, were opposed to such a focus and instead voiced their interest in understanding more about their practice, their students and the community through designing and researching possibilities for CRE in IPL. In collaboration with the district we also sought to hire a community-based researcher for IPL with a strong background in mathematics education. Although the district advertised for such a position no applicants were found qualified to fill the position. This required a closer geographical connection than originally anticipated between the university researchers, the district, community and participating teachers. As such at least one of the university researchers attended all project meetings in IPL.

Between meetings the group decided on a question or focus that they would each explore within the contexts of their own classrooms and then report back on during the next group meeting. Teachers worked on various tasks, piloted project-developed math problems in their classes, collected copies of students work, digital images and in some cases digital video of their classrooms. Figure 3 outlines the cycles of imagining possibilities as a group, planning problems for classroom settings, acting or trying the problems in classrooms with students, and evaluating what was learned individually and collectively. The completion of one cycle provided the substance and experiences needed for further re-imagining and exploration of the next cycle.

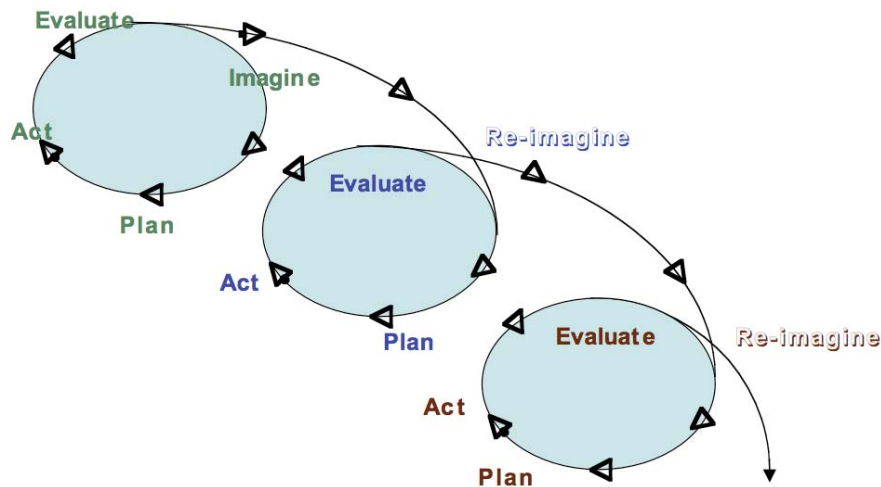


Figure 3: Participatory action research model outlining multiple cycles of teachers coming together to imagine CRE possibilities then researching these in their classrooms.

Participation in the study involved following university-based ethical protocols and the IPL agreed upon and understood protocols. The university-based researchers developed, at the request of the IPL Director of Aboriginal Education, a draft set of protocols that could be used by the district for future research partnerships. The project initially received the support of the district superintendent followed by support and approval by members of the district's Aboriginal Education Committee. Participation, progress reports and confirmations were made with regular (generally 2 per year) presentations to the Aboriginal Education Committee.

Data Collection and Analysis

All group meetings were video or audio recorded providing a total of approximately 130 hours of records (Table 2). The purpose of recording all group meetings was to capture the language, discourse, questions and issues that arose for participants in the meetings. Participating teachers completed a questionnaire (Appendix A) at the beginning of the project and a slightly modified questionnaire at the end of each of the first two years of the project (Appendix B). Teachers also participated in individual interviews (Appendix C and D) throughout the project. The purpose of the interviews was to gather insight into participants' experiences and perceptions. The interviews were semi-structured in that they were guided by an initial set of questions but were shaped by participants' responses. These interviews were approximately 45 minutes to one hour in length and were audio recorded then transcribed. Interviews were conducted by research assistants who were outside the project and not familiar to the participants as well as by the

Principal and co-Investigators of the project. Interviewers outside the project provided a distancing of the interviewer to the interviewee that allowed participants to share thoughts on both positive and negative aspects of the project. In contrast, interviews conducted by project researchers allowed for more wholistic and interconnected discussions that could draw upon ideas, reflections and comments made during project meetings and classroom visits. All interviews varied slightly and were guided by responses to the previous interviews and by researchers' observations.

Table 2
Data Table: Number of Project Meetings in IPL by Year

Month/Year	2006	2007	2008	2009	2010
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					

The questionnaires and interviews were designed to gather information about participants' perceptions about math, teaching and learning math, the place and role of culture in teaching math and other subjects, and to learn about the degree of confidence these participants had about their own mathematics teaching that might be culturally responsive. A goal of the interviews was to engage participants in articulating their views of culturally responsive mathematic education and the challenges and extent to which they felt able to enact aspects of culturally responsive pedagogy in their classrooms. Other data sources included university researchers' field notes and documents provided by the district outlining the district goals and action plans. As soon as possible after each meeting we held an audio-recorded debriefing session of the university researchers to share ideas, questions and concerns that were often further articulated or explored in our researcher journals.

Following each project meeting we listened to the audio or video recordings of the meeting and took notes of salient events and conversations. The notes contained annotations connected to a specific detail in the audio record, situations that were surprising or contradictory, comments that were intriguing or interesting that could be followed-up at the next project meeting or through an interview, and snippets of discussions that were transcribed. Our notes also included comments about data collection methods, documents to collect, and emerging ideas. In listening to the audio

records we also made detailed notes that included transcribed excerpts connected to specific recording times that would allow easy access of data retrieval.

All video recordings of project meetings were downloaded to Quicktime movies and burned to CDs. For all project meetings, a data summary sheet was created as soon after the meeting as possible. This summary listed the various activities that comprised the meeting, the type of data collected, handouts and digital presentations used, key points gathered from the debriefing sessions, questions that arose from the debriefing session, and points to follow-up. One focus of these notes was to track the main ideas or themes of the meetings across the year. Graduate research assistants completed time coded tables for each project meeting. This involved charting the meeting activities and the topic of conversation every 5 minutes.

The research described in this report seeks to understand culturally responsive mathematics education by looking closely at how it is conceptualized and lived by a group of teachers in a participatory action research project. In general the research reported is qualitative in nature and is based on the analysis of teacher questionnaires, video and audio recorded data of the project meetings and audio recorded interviews with the teachers. Furthermore the teachers in this study were also collaborators, helping to collect data, present their experiences and share their ideas. Teachers collected data in their classrooms that included video records of lessons, digital images of students working on selected problems, and copies of students' work. They shared these data with the group during our project meetings.

Analysis for this report focuses on the questionnaire, project meetings and teacher interviews and is supplemented by some teacher collected data. First we analyzed the teacher questionnaires by organizing the responses in a table of participants' responses across questions. This allowed for the analysis of both quantitative and descriptive data (written responses) to be analyzed by question across all participants. Second, after watching and/or listening multiple times to the video and audio recordings of one of our first project group meetings (August 2006), and using researcher field notes as well as our data summary sheets, we identified sections of this project meeting that would provide further data on participants' initial conceptions of culturally responsive education. These sections of the August 2006 meeting were transcribed producing 10 pages of text. A similar process was conducted for data from project meetings collected between October 2007 and June 2009 (23 meetings in total) but in these cases we identified sections that would provide data on participants' learning about culturally responsive education and their experiences practicing it in classrooms. These sections were also transcribed producing an additional 158 pages of text. Preliminary data analysis then involved coding these sections for the content of discussion, the kinds of questions asked by teachers, the disagreements and surprises as well as changes in teachers' thinking related to culturally responsive education.

Next, we analyzed the transcripts of all interviews with teachers; this included both formal interviews and informal conversations. Participants were given the option to read over their transcripts and in some cases changes were made. Preliminary analysis

involved the university-based researchers analyzing the interview transcripts independently by making comments and highlighting themes that occurred within and across interviews. These themes were coded and then discussed collaboratively to compare interpretations. The transcripts were reread and re-coded to refine and verify or extend our initial interpretations. A table was developed for each participant that included interview excerpts around the categories of conceptions of culturally responsive education, student experiences, memorable events, and issues. These general categories were then further analyzed to describe the perceptions of these seven participants and their experiences in the project to date. An audit trail of transcripts of interviews and project meetings along with researcher field notes established some degree of confirmability. Storywork methodology guided all stages of data collection and analysis as we considered the story to be told with these data and the respect, relevance, reciprocity and responsibility needed to research *with* rather than *on* project participants. The data are articulated around four major themes focusing on: 1) project teachers' initial perceptions of CRE; 2) how they designed and practiced culturally responsive pedagogy; 3) what they learned about culturally responsive education through their participation in the project; and 4) teachers' developing conception and articulation of CRE through their living model of CRE in practice.

Researchers' Identities: This project involves the work of Indigenous and non-Indigenous educators, researchers, teachers and community members. This particular report is a collaboration of two university-based researchers (one Indigenous and one non-Indigenous), two teachers (one Indigenous and one non-Indigenous who is also a graduate student), and two graduate students (one Indigenous and one non-Indigenous). For us the roles of teacher, researcher, community member and learner are delicately intertwined. We are in our own ways active members of our communities seeking to improve the quality of mathematics education for all students. In working with community members and collecting and analyzing data for this report, the fact that one of us had taught and lived in the area, that another was recognized nationally and internationally for her work with Indigenous teacher education, and that others were practicing mathematics or science teachers were obvious strengths for us to create and develop relationships with community members, teachers and students.

Part 4: Findings

The focus question for this report is:

How do IPL teachers' involvement in a participatory action research project influence their understanding about culturally responsive pedagogy in the context of mathematics education?

We examine the following research questions:

- 1) What are IPL teachers' initial perceptions and experiences of culturally responsive mathematics education?
- 2) As IPL teachers participate in the project how do they practice culturally responsive education and what does it mean to them?

- 3) How can participatory action research and Indigenous storywork methodology be potential tools for professional development in the context of mathematics education?

For this report we present two sets of findings. One set focuses on teachers' perceptions of culturally responsive mathematics education, teacher's reports of how they live it in their classrooms within IPL, and their living model of CRE. A second set of findings focuses on the use of participatory action research and Indigenous storywork as a methodology for this study and examines the suitability, potentiality and possibilities these offers. Through this second set of findings we examine teachers' learning from involvement in this participatory action research project and how it influenced, and in some cases transformed, their practices

Teachers' Initial Perceptions and Experiences with CRE

In our beginning meetings teachers responded to an initial questionnaire (administered during Project meeting May 2006) to gather information on teachers' mathematics, cultural, and pedagogical backgrounds. Analysis of these questionnaires indicates that teachers reported interest in the project to develop culturally responsive education in mathematics for various reasons and with various concerns. Although concerned about the possible constraints on their time and the challenge of pursuing the possibilities of CRE in provincial examinable courses all five teachers rated their initial level of enthusiasm for the project as high. Participants hoped the project would provide them with "resources that are applicable, easy to use, accessible, relevant and connected to the curriculum" or "creative methods for passing on skills to varied levels of learners."

When asked to comment on the extent to which they drew upon the community in teaching mathematics 1 of 5 teachers stated they did so. Kit for example stated "I try to pull in fishing, berry picking and hunting of deer population whenever possible." Others stated that they "haven't found out how to easily tease out the math concepts and find ways to teach [these concepts] effectively" or "I hadn't really considered teaching with culture in mind." Similarly few teachers reported drawing upon Indigenous culture in their mathematics teaching. As one teacher reported "I use it very little because I am afraid of offending anyone by getting things wrong." Four of the 5 teachers reported satisfactory to poor knowledge of local Indigenous culture. Interestingly, those who were new to living in IPL rated their knowledge as poor as did those who had resided in the area for many years.

At the beginning of the project teachers were asked to comment on what they thought helped students learn mathematics. Four of 5 teachers mentioned that practice and concrete materials or manipulatives were key to supporting students' learning. One teacher mentioned "experience and the ability to create their own awareness of mathematics" while no teacher stated that connections to culture or community were significant for student learning. They reported that students did not enjoy mathematics when it was not well understood or confusing and boring, when there was seatwork and practice, and when students felt they were not successful. All but one teacher described a

typical math lesson for them as including “review of previous day’s work, quiz at the beginning of week, homework questions, lesson, check homework.” One teacher, in contrast, described teaching mathematics in the primary grades as integrated across the curriculum.

Teachers’ rated their own understanding of mathematics for teaching as satisfactory to good. Their experiences with mathematics varied. All were successful with university level mathematics courses. Although successful not all enjoyed it. One teacher who received A’s in university mathematics stated: “I don’t consider myself a math whiz. I don’t dislike it. I believe I’ve forgotten lots because I don’t use it.” While another commented, “My background is not math but ... I believe anyone is capable of learning math.” Teachers’ confidence with mathematics was related to their confidence in teaching mathematics effectively and ranged from satisfactory to good. They were also reasonably confident in their effectiveness in working with mathematically weak students yet were challenged with meeting the diverse needs of their students. This teacher’s comment is representative of others: “I find it difficult to make time in the class to help those students who struggle and at the same time challenge those who need it.” Although teachers generally did not consider Indigenous Knowledges, culture or the community as resources for mathematics problems they did speak to the need to draw upon students’ prior knowledge in designing mathematics lessons. It gave them, as one teacher stated an opportunity for “seeing where students are at and to know where to start.”

Kuat, the local museum curator, confirmed teachers’ self-reported unfamiliarity of IPL cultural values and knowledges. As an artist and of First Nations ancestry Kuat’s position as curator involved managing the museum installation as well as developing public and educational programs to explain and interpret IPL weaving, pole carving, canoe building, song and dance. She has developed an exhibit on cultural appropriation and an educational resource using the canoe as an entry point into understanding IPL culture and how it has shaped IPL culture. One of the main challenges notes Kuat is that “many teachers don’t really have much of a comfortable knowledge of IPL culture ... even though the school district would like to have 15-20% of its curriculum include IPL material” (Interview December 2008).

Kuat’s observation is also seen in one of the first project meetings where teachers discussed their understanding of IPL culture and what they would like to learn more about. At this meeting teachers felt comfortable sharing their questions and experiences with each other.

Miki: One question I have is around native values that have been pushed out or suppressed and we are looking at what are the IPL values in education? What do they want for their children? ... I know what my values are as an individual, but maybe I’m missing out on a lot of values that are deemed important that I have no idea that I’m missing based on my value system. Is it possible to know what these are?

Kit: Yeah, What is the IPL ideal? What are the values?

Miki: What are the values of the whole community ...that the school, and the kids can and everyone is striving for – embracing this idea, and striving for it through math or reading?

Cynthia: ... well your students could be your resourceyour teacher. (Project meeting August 2006)

The teachers asked themselves these questions as they juxtaposed their own values alongside those they recognized in the community. A sense of humour was mentioned. Active talk and play, conceptualized as “the audience not listening” during feast speeches, and lack of time management were also mentioned. However, they did not pick up on Cynthia’s comment about students being a teacher’s resource, or students being a mentor to teachers. Although they spoke about stereotypes and the challenges of not making, what Kit referred to as “snap judgments” about their students and their families, they most often spoke about what they knew in terms of what their students didn’t do or know. They did recognize that what they knew about their students’ background was not enough. Miki insightfully asked “how might I be stuck in my own values and not even know it?” That prompted Kit and then Darren who was quiet through much of this discussion to respond:

Kit: What are the IPL cultural little innuendos? ... And how would I use any of this in my math class. It might help me understand where my students are coming from but not really how I should teach them...

Darren: The family is really huge in our culture. What I’m glad to see is ...the cultural aspect of things. I think our language is key to keeping that connection with the Elders and the younger generation. A lot of our Elders participate in that and our stories are well documented every day. ... Somehow that will transfer or trickle into our own high school curriculum, hopefully ... more than it is now... (Project meeting August 2006)

This excerpt and the previous excerpt are examples of how participating non-Aboriginal teachers in the group did not readily consider their own students nor each other as resources for learning more about IPL culture. The conversation continued until Darren felt comfortable contributing what was important for him in his IPL culture. The excerpts also indicate how the teachers were searching for over-arching cultural values of IPL that could describe all IPL people as sharing the same values. Darren noticed this and responded.

Darren: I guess I see there’s a certain number of families that engage in cultural activities and some not so much. ... For myself, if someone asked me ‘what’d you do this summer?’ I’d say that I just stayed close to home. To me staying close to home is food gathering. Participating in cultural activities like potlatches, just being actively involved in ...what would be considered the traditional background- picking berries, smoking fish, and eating our traditional foods. Just being with family. I mean it’s seasonal too right? There’s not a lot - there’s a lot of families that do that, but a lot just don’t. I think that’s really the big gap. (Project meeting August 2006).

The teachers recognized the lack of IPL culture and values in the schools and classrooms where they taught but were unsure how to teach with or from a cultural point of view. This was case for Darren who rated his knowledge of local culture as excellent: “I’m

living and teaching in my home village ... half the students are my relatives” and also stated: “I hadn’t thought about involving the community in teaching math, but I can see there is potential.”

In summary participating teachers at the high school level described their typical mathematics lesson plan as following the routine of: “review of previous day’s work, quiz at the beginning of week, homework questions, lesson, check homework.” At the primary level mathematics lessons were more integrated across the curriculum, while the intermediate level resembled high school math lessons: “work through problem on board or overhead, worksheets/textbooks, games/manipulatives.” Most teachers stated they did not regularly draw upon community or culture in designing their math lessons and although they recognized the importance and potential of community resources they were unsure how to design and implement lessons that could be thought of culturally responsive. They did not explicitly consider their students or each other as resources for learning more community values and practices. However, this stance changed as the project progressed. As participants connected with community members, brainstormed ideas for ways to connect mathematics, community and culture, and piloted ideas in their own classrooms they began to see themselves as culturally responsive educators. In the following section we examine how, with inspiration from project meetings, teachers explored culturally responsive education in the context of their own practice and shared their understandings of this with the group.

Practicing Culturally Responsive Mathematics Education

Teachers explored the nature of CRE through their practice by: 1) trying the same problem, with adaptations for their specific grades, in their own classrooms; and 2) developing their own classroom CRE projects. It must be emphasized that the university researchers did not provide project teachers with pre-made, pre-packaged CRE curriculum for mathematics education. Other curricula, such as Lipka et al’s (2007) *Mathematics in a Cultural Context* were shared with teachers as examples of what is possible. However teachers recognized that CRE for IPL could not be imported from elsewhere and implemented as is. Developing materials, lessons and projects would Carol states “requires us to think deeply about this place, who are students are, and what math is” (Interview December 2008). The following sample projects provide evidence of the kind of action and outcomes that are possible with participatory action research in the context of CRE for mathematics teaching and learning. Two collective group projects and one individual project are selected as representative samples. Before we examine these group and individual projects we first describe examples of the stories and experiences shared by community knowledge holders and Elders that became the foundation for teachers’ collective and individual projects.

Learning about Indigenous Knowledges through Storywork with Community Elders

Community knowledge holders such as well-known artists, storytellers, Elders, and community organizations such as a local museum participated in the research process. The teachers learned about the Indigenous Knowledges (IK) of the IPL through hearing

traditional and life experience stories told to them through meetings and visits to the people's cultural sites. Community artists, for example, visited and talked about IPL Knowledge, culture, and values.

During the sessions, the community knowledge holders reminded the teachers to appreciate the knowledge expertise of Indigenous people, and to think of math in a very different way as shown in this quote of a well-known community artist.

Last night someone asked if these images tell a story. Boas, [an anthropologist] showed a beautiful box that was probably made around 1890, to [well known early IPL artist] who was a master artist who lived the culture, knew the stories, and Boas asked him what does this [design] mean? So [the artist] recited a Raven story from the box and Boas in his brilliance found the story a bit fanciful. Here is this outsider from New York doubting the [Indigenous] master and also one of the leaders of the culture that breathed and lived culture. So the meaning part; What is math? Like meaning could be made to make math interesting...It is up to us to tell our story, to give it our meaning. For example, when we are fishing, I am cleaning fish and I am putting fish on the rack any old way. My Dad said to put the salmon heading up stream because that ensures the spirit to always come back. So if there is some kind of spirit in math, math is a spiritual being that helps to develop your mind (Project meeting October 2007).

Community knowledge holders who met with project teachers spoke about Indigenous Knowledges in similar ways to Archibald (2008). Indigenous ways of knowing were described as being experiential, storied, relational, contextual and wholistic. This can be seen in this community artist's description of IPL art:

The art does come from nature, art does come from nature – it comes from the patterns you know when you slice the fish and all the patterns are in the slice, the patterns on the beach – clam shells, muscle shells, ... the skulls, the skeletons, the two shapes are in all that, in nature.

A further example highlights how discussions about positive and negative space when drawing became places to be reminded of IPL values: everything is connected and inter-related. As this community artist told the group when discussing the story within a killer whale design:

This is a really profound design; this is a killer whale – the eye, the mouth, the snout, the pectoral fin, the body, the dorsal fin, and tail. There are two things happening – the positive - the killer whale, and the negative- the space that is left out. And what is so profound about this is the ability to design around this really odd shape and here is the backbone of the killer whale. So you are looking through the body like in mythology when we are in the killer whale world we see them as humans and when we are going into their realm being in the water it is no different than being in the air we can still breath still breath when we are in the super natural realm... So the positive is as important as the negative. Today everyone focuses more on the positive

“I want a good experience”, but in order to have a good experience you need to be reminded that you are having a good experience by being reminded by the negative. This line is so profound!

Such discussions were understood by teachers in different ways. The discussion of positive and negative space, for example, led some teachers such as Shal (an IPL teacher able to attend 3 project meetings) to consider what this meant for her as a teacher of mathematics. She asked the group and visiting community members the following question:

What I am finding is that there are some students that I really want to ensure they have some positive successes and positive experiences in their math class ... and I am having a hard time getting to that place. ...I am realizing too that it probably has to do with trust issues. They don't trust me yet. Because they don't really know me yet. I am only really new to the school though I am not new to IPL I am newer to the North end and newer to probably all of the kids except for a very few of them who I know through family and friends before, so how do we have, is there any brain storming we can do about achieving some trust and some positive math experiences that incorporates all of these ideas? (Project meeting August 2007)

Through opportunities to hear IPL stories told to teachers by community knowledge holders and Elders, and to discuss IPL stories through art, dance and nature teachers become more familiar with IPL cultural values. These opportunities existed throughout the project and continue to exist as community members collaborate and participate with teachers in this project.

The process was not only valuable for practicing teachers but also for community members. One well-known community artist stated that being invited by the district to speak to teachers and to meet with TEAM-Learning project teachers was the first time the school district had ever invited him to share his knowledge in this way. He was honored and pleased to make such a contribution.

We turn now to describing and analyzing the ways participating teachers worked with community knowledge holders through storywork methodology and participatory action research. We have chosen three examples as they highlight and provide evidence of the kind of action and outcomes that are possible in exploring the nature of CRE. Two collective group projects and one individual project are selected as representative samples. The *collective projects* were developed by the group with a common or shared question. Each participating teacher worked on the shared problem within his/her classroom, adapting the problem to fit his/her students and grade level. In addition to the collective projects, teachers also worked on classroom projects that were of specific interest to them, and we refer to these as *individual projects*.

Working with Stories - Raven Brings the Light: Collective Project Example 1

During the third group meeting teachers questioned how they could attend to emotion in the class and work with students who fear math, doubt themselves as doers of math, or

are angered by doing math. Given the prompt “What might an emotionally healthy mathematics classroom look like?” teachers brainstormed responses that included: trust, respect, listening, inclusiveness, risk taking, acceptance of difference, caring, co-operation, and hopefulness. Teachers also discussed how mathematics curriculum and school practices often exclude students through the types of word problems, examples, and teaching strategies chosen and valued. As a result teachers recognized their need to learn more about Indigenous Knowledges and culture and how they might, as Aboriginal or non-Aboriginal teachers, gain access to and teach through such understanding.

Community members were invited to the project meetings and shared their views about education of IPL students, IPL artwork, IPL Indigenous ways of knowing, and cultural practices. A number of meetings involved the attendance and participation of the IPL Heritage and Language coordinator. In response to the group’s interest in the potential of oral stories for exploring mathematics the coordinator shared with the group a compilation of IPL oral stories performed and told by Elders and youth of the community. A digital version of the stories was available for public use and the group was given permission to share the stories in the classrooms. During project group meetings teachers listened to the stories and marked sections that could inspire opportunities to explore mathematics. The story, *Raven Brings the Light*, involving a series of nested bentwood boxes became an agreed upon context for an interesting mathematics problem.

Raven Brings the Light (as told to the group from the Old Massett Legends)

.... Now Yaalth, the Raven, was getting tired of only darkness. He had heard of a great sky chief who was said to have all the light in the world. Raven decided that he would have to spy on the sky chief.

He saw through the misty pale darkness that the chief had a daughter, and he watched as she went to get herself a drink of creek water. Raven could change his shape and transform into anything he wanted. So as she dipped her cup into the water, Shapeshifter Raven turned himself into a hemlock needle, and floated down the creek. The young girl scooped him up with her cup, and swallowed him. And then he was inside her.

As he was growing up Yaalth acted like any other child, and made a lot of noise when he didn’t get what he wanted. And he knew his grandfather kept ‘all the light in the world’ inside many bentwood boxes, and that’s what he wanted. Day after day he would cry, “Box! Box! Open the box!” until his grandfather opened one box. There were ten boxes, one inside each other, and after many days, they finally came to the last one.

It was a perfectly round ball of light, brightly shining, and raven played with it and rolled it all around the longhouse. ... But Yaalth wanted to take the light away, and so he changed back into his raven form. And he was a pure white raven. He snatched the white light with his beak, and flew

away with it, up through the longhouse smoke hole. Only he became stuck and covered in soot, and turned completely black before he could fly away

He flew as high as he could with the white light in his beak, but he couldn't fly high enough, so he began to break the light into pieces. And then he spat them out, into the sky. The small pieces became the stars, and a large piece became the moon. And then he asked an eagle if he would take another large piece high up into the sky, where only the eagle can soar, and he did, and that became the sun.

After that there was light in the world. But raven has stayed black forever.

Teachers brainstormed the following mathematical ideas after listening to the legend at one of the project meetings (Project meeting November 2007)

- Students could calculate the volume of the sun, ... the light
- They could explore what is meant by infinity. "All the light in the world." (a quote from the legend) What would that be?
- Compare surface areas and volume of the nested boxes
- Transformation – the idea of shape shifter as changing. So this could carry over to concepts of mathematical transformations: rotations, tessellations, symmetry ...
- Comparing the sizes of boxes. How big or small do they need to be so that they can be nested. ... How could a lid be made for the box?
- The ball of light becoming the sun, moon and stars. Could explore size – how big is that? How many stars? How big is a million?
- How does paper size and shape affect the box shape?

They also wondered about the cultural meanings of the legend and asked each other how the story could be a place to not only explore mathematical ideas but also IPL culture:

- What about Raven? Raven as problem solver, trickster... what would Raven do if he were stuck and couldn't figure out how to solve a [math] problem? How would he creatively solve it?
- Transformation ... we could build on transforming ... the idea of getting unstuck. Transforming the problem into something that can be done. How to change the situation, as Raven did, so that it can be solved. Using what we know to solve something we don't know.
- Seeing or bringing the light as understanding math – that Ah-ha! moment.

In summary, teachers brainstormed mathematical opportunities within the story such as the mathematical concept of transformation seen through the shape-shifter metaphor, nested boxes and counting sets, the mathematical properties of a box, and calculating volume for different sized boxes. They also explored ideas around the cultural meanings of the story and how they could incorporate the story in classroom discussions beyond the math problems. Teachers began to see the mathematical and cultural potential of the legend.

The idea of building boxes from paper was suggested and teachers worked the problem themselves first, exploring relationships between the size of paper and size of box produced, determining the paper dimensions for a lid to the box, and wondering if it would be possible to build a very small box. They collectively engaged in mathematical and pedagogical inquiry, exploring both the mathematics in building and comparing boxes and the kinds of inquiry questions they could ask their students. The teachers commented that they were encouraged by their own motivation and engagement with the problem and were excited to try it with their students. However not all teachers felt ready to try this problem with students. Maria for example felt that she and her class were not ready for a problem that was so different from what was typically taught in math class. Considering the class Maria had that year she remarked:

I can't take them out of my room or try something different because they would be all over the place. They'll see it as a chance to goof off or goof around. ... What I'm trying to do is to establish a routine. So that they know what is going to happen when and what is expected of them. Everyday there are detentions... (Project meeting January 2008)

For Maria she felt she needed to have a defined structure with her students, a pedagogical relationship that would allow her to try something different from what students typically expected in math class (i.e., working from a textbook). She had not yet built the trusting relationship with her students needed to explore a different path. An Elder and well-known artist from the community stated during a previous project meeting to the teachers "Trust is a big thing! Trust is very important and maybe that is something that is learned. We learn pain and that causes mistrust and that emotion is carried many lifetimes..."

However some teachers felt they had developed the trust and were comfortable taking the risk to try introducing a math problem through the Legend. In posing the problem to their students, some teachers asked their students to first listen to the Legend as told by community Elders, other teachers read the story from a picture book. Students were asked to build nested boxes from paper and to explore the relationships between surface area, volume and perimeter. The primary teacher adapted the problem by asking students to take apart cardboard boxes and rebuild them, while the intermediate and secondary teachers asked students to build multiple boxes and explore the mathematical relationships.



Photos: Students building paper bentwood boxes to explore volume and surface area after listening to the Raven story

Over the next four project meeting teachers shared their experiences posing the Raven Brings the Light problem in their classrooms. It took some teachers such as Kit time to feel comfortable moving outside students' expectations for how they should learn mathematics. Although she had developed a strong relationship with her students, she was not comfortable with herself and questioned whether or not her Grade 9 students would take it seriously. Nonetheless Kit did eventually try the problem with her students. Teachers collected digital video and photographs of their students working on the problem and shared these with the group at the project meetings. In reflecting on their experience the following dialogue is an excerpt that took place among the participating teachers (Project meeting May 2008):

Kit: My students were totally into it. I couldn't stop them from making boxes. They were measuring, comparing, building...

Darren: I noticed a couple of the kids who [usually] have a hard time [in math class] were really engaged. They actually finished building a box and stayed on task for the entire class - without much extra support.

Maria: Yeah, I was surprised at who could follow directions [to build the box] and who needed step-by-step instructions. Some just got totally frustrated and gave up, but most built lots of boxes of different sizes. What was challenging was trying to get students to think about the math – to get them to ask questions rather than just build boxes. I really wasn't sure how to ... ask good questions that would get them exploring on their own. It's so different from the kind of math we usually do.

Cynthia: ... In what ways?

Maria: The students really like working out of the math book, its structured, they know what to expect, we first practice a few examples and then they work on their own. But this problem [Raven] I think is too different for them – some really didn't know how to act, what to do, or how to ask a question. I'm not saying that this problem is bad only that students, just like me, will need to learn how to work in this more open kind of style. Some said they really liked the connection to the IPL Legends – something that doesn't happen in [math] class.

Kit: I know – it made me realize that I need to ask more open questions.... but I really wasn't sure how Grade 9 students would react to listening to the Legend. ... I was kind of reluctant to try – but really surprised - that they loved listening to it....

Miki (who chose not to try the problem with her primary students): what I noticed is how you were all able to try it [the same problem] but adapted to your classroom.

This conversation captures the questions teachers had about implementing a CRE lesson they had developed. This was one of the first tasks they had developed and tried as a group. Their focus on inquiry is evident, as is their interest in storywork. The task challenged their assumptions of what students would be interested in doing and learning, and what students could do. They also recognized the interactive and flexible nature of an inquiry-based problem, which parallels the dynamic and complex nature of culturally responsive teaching. The conversation provides evidence of teachers' initial reluctance or hesitancy to work with stories in the classroom, particularly at the high school level, and their surprise that most students enjoyed listening to the story, recalling the story events, and working the mathematics.

Teachers' articulation of student engagement is also evidenced in their debriefing of the problem a year later in a somewhat different context. At this point in the project we scheduled time to collectively design a problem, try it in one of the project teacher's classrooms while the other teachers observed, collected images of students working and informally interviewed students about their experiences on the problem. The group observed Darren pose the Raven Brings the Light Legend and nested boxes problem to his Grade 5 class. An excerpt from the debriefing meeting that followed highlights the energy and possibility the group witnessed. The excerpt begins with teachers recounting how two students who seemed to be disengaged at the beginning of the lesson were totally involved by the end (Project meeting June 2009):

Darren: I was really shocked that he focused and stayed with it because this was completely new to him. So that was awesome. And Carol [project teacher] working with [student] and he is very, very low level - maybe he is working about the Grade 1 or 2 level. So for them to do the nested boxes example was just outstanding.

Miki: That little fellow said "That was so fun!!!"

Maria: It think that is the best part – seeing how thrilled they are. Because at the end, when you were talking about his boxes, he was just glowing.

Darren: We could do next class – What would happen with different sized paper?... and ask them to go ahead and prove it. Maybe more talk about volume, area, and perimeter. Or to make a lid.

Jess: How would you make a lid though....

Miki: That's a good question...

The teachers moved from talking about their observations of students and what they noticed about student engagement to how they themselves would solve the problem that Jess posed. Teachers' attention shifted from students' experiences to pedagogical consideration of further extensions to the problem that eventually resulted in opportunities to explore mathematics. Respectfully observing and discussing student work on the problem and their own understanding of possible problems are examples of teachers living CRE through storywork.

Seeing Math In IPL: Collective Project Example 2

A second collective project with teachers focused on exploring the possibilities of mathematical relationships in the environment. Teachers were given digital cameras and invited to collect images of events, the land, and activities that could inspire mathematical problem solving. We began by taking 'math walks' together through the local museum, the beach, and forests where we shared genuine questions and knowledge about the area and brainstormed possible problems that could be posed in mathematics classrooms. Together teachers collected more than two hundred images, collectively edited and selected a set of 75 images and then developed mathematical problems around 40 of these images. Developing, adapting and writing mathematics problems was a challenge for all participants. Eventually three math photobooks were produced that

include math problems, mathematical extensions and cultural background knowledge of for each photo and accompanying problem.

The group devoted many meetings to examining strategies for designing open-ended mathematics problems and for deciding on which photos were worthy of consideration for developing problems. As resources we drew upon research on developing and using worthwhile mathematical tasks (Henningesen & Stein, 1997, Sullivan & Lilburn, 2002; Gutstein, 2006) and upon Elders and knowledge holders of the community. This particular collective project provides opportunities to examine where teachers see mathematics. It presents a set of provoking questions that extends previous research in this area (e.g., Brag & Nicol, 2008; Crespo, 2003; Nicol, 1999). How do teachers see or notice mathematics in their own and their students' lives? In what ways do they pose mathematically, pedagogically and culturally rich problems for their students?

The teachers collected a varied set of digital photos that were more often inspired by the beauty of the IPL area and less often by mathematics. This is understandable. Teachers have had few opportunities to imagine or explore mathematics outside the textbook. Maria details her strategy for collecting images:

At first I took photos of anything that looked like it would make a good photo and what I thought could be made into a good math problem. But it wasn't always easy to come up with a problem related to the photo. Then I started to take photos by first considering the math and then finding a context that matched that mathematical concept. (Project meeting December 2007)

Thus, Maria took photos inspired by the beauty of the context and although she had a strong mathematical background she, like other teachers, found it a challenge to explore the mathematical possibilities within that context. In this case some photos were taken by teachers to illustrate a mathematical concept rather than finding photos that could ground or situate the problem. However as the project progressed teachers became more comfortable posing open-ended problems and refining problems for their students. The following are examples of photos and problems developed by the teachers and refined by the group.



Math Photobook Problem 1. What is the ratio of the length to the width of a razor clam shell? Does this ratio hold for different size shells? Where else do you see this ration?



*Math Photobook Problem 2:
How many different ways could these 12 buoys be put into two groups?*

An important aspect of this collective project was its openness for teachers to adapt the problems to their own grade level and students' interests. The primary teachers asked students to show different ways to make 12 using numbers, pictures and words. The secondary teachers such as Kit asked students to pose a problem inspired by the photo. Kit describes the process with her students of sharing a poster size photo from one of the photobooks.:

... there was one [photo] with a bunch of floats ... I asked the kids (Grade 12) to come up with questions from it ... and they started playing with permutations and combinations: 'how many different combinations can you come up with this many colours? How many different ways can we organize those floats by using permutations and combinations.' So that was cool. (Interview December 2008)

Kit further describes the excitement she noticed in her students when the students solved problems related to another photo taken by one of the teachers in the group. This photo captured multiple stacks of crab traps waiting by the dock for next crab opening.

And then there is one with crab traps. 'Hey, that's just over there' (in the voice of her students). ... The excitement is huge, huge excitement, it was one of the first times I'd seen the entire class get excited ... because it wasn't something we were taking from Vancouver, and it wasn't something we were taking from the States. It was like 'Oh, my gosh, there is this big poster of HERE! Wow.' It was pretty cool. (Interview December 2008)

For teachers such as Kit, the photobook project brought mathematics, culture and students together. In some ways it provided Kit with new insights into her students - what they knew about where they lived and what intrigued them. In the case of the float and crab trap problems it was the fact that mathematics could be about something other than a textbook problem typically grounded in a setting far from IPL.

The teachers spoke about how the photos as representations and images of life, place and culture in IPL inspired new possibilities for them in terms of seeing mathematics outside the textbook and classroom walls. This process provided them with a sense of ownership of their questions and empowerment to create math problems in other contexts. Miki's comment is representative of all the teachers when she stated, "I can't not think about math now when I'm walking outside, hiking or doing something outside. I keep seeing everything as a potential math problem. ...It's all so connected." (Project meeting May 2008).

The photobook project provided opportunities for teachers to explore local culture, develop and pose open-ended mathematics problems, and learn more about what excited and interested their students. However all teachers said that developing math problems, particularly open-ended problems was a complex process. Not all problems developed could be considered mathematically interesting. Furthermore, most problems created by teachers were developed for students rather than for the teachers themselves. That is, teachers found students were excited by the problems and this increased teachers' pedagogical interest in the problem. However it did not necessarily increase teachers' interest in posing or solving mathematical problems for themselves.

Building on Students' Strengths: Individual Projects

Teachers in the project not only worked collectively on a number of projects such as working with oral stories and creating the mathematical problems with digital photos, they also worked on individual projects. Individual projects were developed mainly in the

context of a University of British Columbia (UBC) undergraduate course connected to the project and offered on culturally responsive pedagogy in IPL⁹. All but one teacher in the research project enrolled and completed the course along with 8 other educators and community members. Some of the individual projects included the following: a kindergarten/grade 1 unit developed around a well-known IPL legend that involved students acting out various roles to explore early algebra concepts; a grade 10 unit on the mathematics of building and carving bentwood boxes; a grade 8 unit on the mathematics of canoe building; a grade 2/3 mathematical problem solving photobook with interactive Smartboard problems that highlighted IPL feasts, repatriation, ceremonies and nature; and an intermediate photobook exploring the mathematics of weaving. The details of all these action research projects are beyond the scope of this report. They do provide examples of the range of curriculum development in CRE carried out by teachers and provide evidence of the kinds of changes that participatory action research can engender. However, further analysis of one project as an example, will provide a context to examine the kind of work teachers explored and the reaction of their students.

Miki decided to involve her Kindergarten/Grade 1 class in identifying, extending, building and adapting mathematical patterns. The context of one of her lessons was the nearby beach, a short 5-minute walk from the school. Miki describes the rationale for her context:

The IPL people have lived with and off the land for centuries, it was and is today an integral part of their existence. Many of our children regardless of race and culture are spending more and more time indoors with TV and video games, I wanted to be with them in the outdoor classroom. I wanted to create an experience where the math was embedded in our outdoor fun. (written course reflection May 2009)

At the beach students worked in pairs to comb the beach for natural patterns and materials with which they could build patterns. After patterns were built the class “had a math pattern walk” where they examined each other’s patterns for the core and type of pattern and to tried to extend each other’s pattern. Miki shares further what she noticed about students’ engagement:

Every child was on task, some took longer than others to choose what to do, others got started right away, but time was not an issue. Each child was very pleased with their creations. ... I noticed the children were listening attentively to each other, were eager to see what their peers had created and share what they had made. (written course reflection May 2009)

The students and Miki documented their experiences in a math pattern photobook which, Miki notes, is a classroom favourite. “Students were thrilled to see themselves in a book ... they read the book during their own time in class ... their whole being is lifted when

⁹ The course was titled Re-connecting Mathematics, Community and Culture and was developed and offered by the Principal Investigator, Cynthia Nicol through the University of British Columbia at the request of the community and district.

they see themselves on the page.” These five and six year-olds’ comments about their experience indicate their keen awareness of their pattern representations and their beach experience:

“I liked the way that I made two patterns.”

“It was good to be at the beach and have [my classmate] do it with me.”

“That was fun making our pattern and deciding what to use. I decided on pinecones and [my partner] decided on sand.”

“All I did was put sand first, rocks second then seaweed. Another day when we go to the beach I would make a pattern again.”

“I had fun at the beach, I liked finding things.”

QuickTime™ and a decompressor are needed to see this picture.

Students created patterns: kelp, sand, kelp, sand....

QuickTime™ and a decompressor are needed to see this picture.

Pattern math walk: Students identify and extend each other’s patterns

The beach pattern lesson was part of a series of lessons developed by Miki on noticing, creating and extending mathematical patterns. In other lessons students explored patterns found in IPL art forms in class and through two further outdoor lessons working with local carvers and artists.

Miki’s lessons are an example of how project teachers conceptualized CRE in their own classroom contexts. Miki had made a number of principled changes to her teaching that were inspired by her increasing awareness of CRE and through her experiences attending various community cultural events. Miki’s lessons, like other project teachers, are

designed from building upon children's strengths and engaging them in mathematical activities that are important to them. In her primary classroom this meant more time on experiential learning emphasized on IPL place and culture, and this was balanced with structured learning that asked students to explain their thinking using numbers, pictures and words. A starting place for her lessons was not on trying to remediate students' weaknesses but instead on exploring a context of learning that would be engaging, interesting and invite students to solve very open-ended problems. The students in Miki's class were active agents in their own learning, and these lessons revealed students' interests and multiple competencies to their teacher. Exploring mathematical patterns through IPL art forms with community experts and beach explorations was not something that one could find in a textbook or student workbook or even described in the provincial curriculum. These lessons provide vivid illustrations of how the context of the setting inspired mathematical and cultural inquiry. Miki illustrates this through an example where students used various shells to measure length:

We were measuring with shells ... different shells that are found up here and looking at non standard units of measurement, and the [children's] stories that came from that, like 'Oh that is a razor clam and I go digging for razor clams....,' or, 'I've seen that shell before, there are lots of those....,' or 'there's a scallop shell, we eat scallops.'
(December 2008)

With such lessons the students in Miki's class share the expertise most often afforded only the teacher. Students seek each other out for answers to their questions or readily share what they know about a particular event, animal, food or activity.

The lessons are based in the lived experiences of students and thus increase both the teacher's and her students' cultural awareness. For teachers it provides opportunities to learn more about their students' interests and knowledge. "For some students this kind of problem [measuring with shells] has an important connection for others it doesn't... and it often challenges my assumptions about who has this experience and who hasn't" (Miki, December 2008). Thus, the context of the lessons provides space to explore not only mathematics but also opportunities to discuss the values, practices and traditions as part of the lesson. Miki's lesson and her reflection on it provides opportunities for ways of building different kinds of relationships with students and community members resulting in bringing shared knowledge of the culture and expertise to the problem.

The two examples of collective projects, one using stories such as *Raven Brings the Light*, and the other developing mathematical problems with digital photos of the environment, along with Miki's individual project illustrate the ways in which teachers practiced CRE in the context of mathematics teaching and learning. These projects provide descriptive detail and examples of how teachers developed lessons that incorporated students' cultural knowledge, experience and mathematical thinking. These experiences influenced teachers' understanding of CRE and their views of CRE grew as the project developed. In the next section teachers' understanding of CRE is examined through their developed model of CRE.

Teachers Develop a Living Model for Culturally Responsive Education

The first two years of the project involved the group in exploring various conceptions of CRE found in the literature, articulated by invited community speakers, and shared by university guest speakers. The desire to articulate and refine beliefs and provide a sound rationale for decisions and actions provided the context for the group's efforts to develop their model of culturally responsive education. Some differences in values and beliefs between various members of the group and between the group and some community members emerged. However these differences and tensions were a valuable part of the discourse toward the group's understanding of its shared purpose and what might constitute CRE.

After much discussion, reflection, reading, and with opportunities to examine their own teaching practice, share ideas with each other in the group and present ideas to community members and educators locally, provincially and nationally the group identified the key aspects of CRE as: grounded in place, based on/within stories, focused on relationships, inquiry-based and requiring personal and collective action. These aspects permeated the group's discussions and became a "living model" of the group's efforts to transform mathematics education through CRE in their classrooms. The following highlights the group's understanding of these aspects.

Place

Culturally responsive pedagogy is responsive to the cultural environment in which students and schools are situated. In rural Aboriginal communities this has particular significance where many community members and students have historic or current connections to the land. A sense of place leads to an understanding of historical, cultural, emotional and genetic links to one's surroundings. It offers possibilities for experiencing the deeply interconnected nature of the human and non-human worlds. Smith (2002) describes teaching practices that focus on place to help students become and stay connected to their local contexts in order to better understand the global. A pedagogy of place or place-based education then strives to help students develop a sense of place that is grounded not only in knowing and understanding communities, neighbourhoods, or local regions but also in understanding the interrelationships between our local places and other places in the world (Cajete, 1999). Orr (2004) offers 5 reasons for the importance of local place: 1) we are place-based creatures shaped by the locality of our birth and upbringing; 2) with calls to protect certain places we are more aware of efforts to preserve place; 3) our increased understanding that it will take local solutions to solve global issues; 4) knowing that a purely global focus can obscure the local events and what happens to particular people in certain settings; and 5) realizing that the global economy is not ecologically sustainable – most of the "successful economies" are also destructive of place, people and ecologies (p. 160-162).

The group, in discussion with community members, considered the place, that is the rivers, sea, mountains, trees and lands within and surrounding the community to be key for understanding the interests and backgrounds of their students, the history and ancestry

of the people, and the traditional ways of living off the land. Teachers believed, following Orr (2004) that understanding place, or ‘the local arena’, is important for understanding global contexts of people, issues, and decisions. Teachers did not discern a difference between culture and place. They considered Indigenous peoples’ long living in particular places as intricately tied to their understanding and awareness to the land. As such, the group considered the relationship between culture and place to be symbiotic. As one teacher stated in describing CRE: “we are completely connected to our land, this place” (Darren, January 2009). It is “the culture of the land and the environment ... that is the responsive part ...it is the culture of living here that is so important” stated another teacher (Miki, June 2009). Teachers such as Carol (Interview 1) commented on the seamless interconnection between land and culture: “CRE is so tied to the culture. It is almost impossible to discern when it does not become culture and it becomes the land.” Others agreed with the importance of the lands of IPL as a ‘place’ rather than ‘space’ of learning. Thus a key question and challenge for teachers was how they could create math lessons that were responsive to place. This they recognized was connected to building multiple relationships.

Relationships

Engaging local cultures across all aspects of school life requires the establishment of healthy, trusting relationships with educators, learners, parents and community members. Ladson-Billings (1995) argues that teachers as culturally responsive to their students’ need to maintain fluid relationships with their students, demonstrate a connectedness with all students, develop a community of learners, and encourage students to learn from each other and be responsible for each another (p. 480). Project teachers also spoke about the need to build relationships with their students and how working with CRE provided, challenged and required they continually work at relationship building. This was important to all participating teachers, both Aboriginal and non-Aboriginal. For example, Darren states that CRE “focuses on that relationship with the students and the parents and the community and ... I wouldn’t be able to have these same connections with students if I wasn’t from here.” He further emphasizes that ancestry is important but not a pre-requisite: “I’m privileged that I am of IPL and I can teach IPL students. They recognize me as being someone who is out in the community, that goes to functions, that does his own food gathering...actually being someone who is living the culture and who has lived it, just makes [teaching as CRE] easier” (Interview June 2009). For non-Aboriginal teachers their focus on building relationships dealt with their felt challenges related to being outside or new to the community and district. “It’s a challenge not being from here, even though I’ve been here for a few years now ... to make the connections is so important, it takes time and its not easy to figure out how or who to connect with” (Kit, Interview December 2008).

Although the group spoke strongly about the importance of developing relationships for CRE they did not all agree on how this could be achieved. Maria believes that as a non-Aboriginal teacher she needs to wait for the community to personally invite her to various cultural events even though such events are often open to all community members. She felt structures were needed to better facilitate connections between new-comers to the community and Aboriginal community members. In contrast, Miki, felt comfortable

connecting with local community members, arranging field trips to the artist studios to study symmetry and pattern making, and canoe building. In either case a focus on building relationships with students and community members was key and reminded teachers that CRE “is not on the paper or in a textbook, but here in the culture, land and connection to people” (Miki, project group meeting 7).

Inquiry

Teachers included the requirement that mathematics problems in CRE be inquiry-based. They questioned the inclusion of culture in a superficial or trivial manner and advocated the development of problems that were connected to the issues and lives of students and community members. Culturally responsive mathematics education challenged students with problems, lessons, activities and projects that are inquiry-based. However, for teachers CRE was not defined as lessons, problems or materials. Contextualized lessons were a part of CRE but not all. CRE more represented a pledge or commitment of teachers to develop relationships with students that included mathematics, considered multiple perspectives, multiple solutions, and opportunities to develop communities of inquiry. Inquiry-based mathematics challenged the view that there existed one way to solve mathematics problems, that there was one way to teach it, and one way to learn it. A focus on inquiry provided opportunities to use mathematics to help students make sense of a local problems and issues. Miki explained “forestry, land claims, fishing rights, lineage ... the people are tied in with every aspect.. and math is needed to understand these” (Interview June 2009).

Inquiry-based also addressed teachers’ emphasis that CRE required the teacher to be a learner with students. The culturally responsive teacher, states Darren, needs to “mainly be willing to jump right in there and do it. Drawing on your own personal interest in the area and culture. Through this approach you end up becoming a learner just as much as you do a teacher” (Project meeting January 2008).

Nonetheless, inquiry-based was intricately tied to building relationships. Teachers noted that it was difficult to build a community of inquiry without trusting and respectful relationships. This is particularly the case if teachers move the learning environment outside. The pedagogical relationship between students and teachers needs to be redefined. Teachers need to develop a trusting relationship with their students. “Risk taking” says Miki “I know I can take this group out[side], and I know those safety precautions, and I know they are going to listen to them. So maybe for some teachers, the trust isn’t there with the group... it seems too scary - so you don’t even try and ... you don’t even know” (Interview June 2009).

Storywork

Closely connected to place are cultural stories that include oral stories, language, art, dance, drumming and legends; where traditional knowledge and wisdom is passed through generations. How can cultural stories and legends be a context for teaching and learning mathematics, for connecting students and teachers, and for exploring mathematics? For teachers this aspect involved the community, people’s ancestries, language and stories. Teachers considered story in its broadest sense to include oral

stories and legends as well as traditional and contemporary dancing, drumming, carving, drawing and building. Inspired by a local well-known artist who considered art (drumming, dancing, drawing, carving, building) as the traditional written language of IPL, teachers considered working with stories as a significant element of CRE.

Drawing upon Archibald's (2008) conceptualization of Indigenous storywork, the group came to recognize the importance of respect, relevance, reciprocity, and relevance in working with Indigenous stories in the classroom. This perspective represented a different way of viewing knowledge and knowing. A mechanistic, compartmentalized view of teaching was replaced by a view that recognized the interconnected, wholistic, and synergistic intricacies of teaching. The teachers in the group endorsed the storywork principles as significant elements of CRE. Storywork placed attention on local cultural values that tended to be ignored in mathematics classes. Furthermore, teachers agreed that storywork was something that is embedded in all their defined principles of CRE. The following conversation during a project meeting (January 2010) highlights this agreement:

- Miki: I think CRE is more than traditional stories. For me it is more than connection to stories. Certainly stories are a key aspect but it isn't only oral stories.
- Darren: Yeah,... we need to include dance, music, drumming, language, art... It's living local culture. Celebration.
- Jess: Yeah, everything has a story. And how you bring math stories or how we see things, together with other stories is really important.
- Miki: It's lifework. It's storywork. I think it's part of all the other aspects [of CRE].

Here working with stories and celebrating culture as a living practice become inextricably intertwined. For teachers, storywork requires they establish connections with students, educators and the broader community. It requires a consideration of place and an exploration of questions within a community of inquiry. Storywork requires teachers to risk being learners with and alongside their students.

Personal and collective action

Action and commitment were key aspects of CRE for teachers. Action potentially implies empowerment leading to personal and collective change for teachers at one level and for students at another level. Teachers recognized that social practices and decisions are framed by particular value positions, motivations and vested interests. Action then recognized the importance of personal and collective commitment for change as teachers shared their work and understandings of CRE with each other, community members, and educators. Teachers agreed that culturally responsive education embodies a commitment to transform mathematics teaching and learning. Such transformation is not only at the personal level but also includes working with colleagues locally, provincially and nationally. Action involves critically advocacy. It recognizes CRE as one approach to transforming mathematics education that shifts teachers' perspectives from as Sobel (2004) describes "addressing and remediating" students' deficits to "uncovering and cultivating each child's unique genius" (p. 22). It is a long-term commitment that as Miki

states: “needs to come from the heart of the educator. To say that this is not only my responsibility but it is something that I want to do” (Interview, June 2009)

The model of CRE developed by teachers included key aspects: place, action, inquiry, relationships and storywork stemmed from teachers’ examination of their developing practice as culturally responsive educators. For some, such as Miki, storywork was both a significant aspect of CRE itself and at the same time embedded in all other aspects. “I think storywork overlays on everything... It ties into each aspect of the model.” It highlights the importance of responsibility, reciprocity, interconnectedness, wholism and synergy of Archibald’s (2008) Indigenous storywork model. Although teachers were presented with Archibald’s model at the beginning of the project it was not until two years later with extensive opportunities to discuss and practice CRE that they were able to articulate their own model of CRE; and for some, such as Miki, embrace storywork in its most wholistic form. The resulting model encompasses teachers’ work over the past three years, their collaboration and critical examination of CRE. In reviewing the work that had been done and the model itself, the following dialogue occurred among participants (Project meeting January 2010):

Cynthia: The model becomes a way of *making sense* of CRE ...
Darren: It’s practical and based on here this *land*, people and stories...
Miki: Yes, it’s a way of looking at teaching math ... but it’s way more than what’s on this paper ...
Cynthia: It’s *organic*
Jess: Well, it’s something we live. It’s more the feeling than ...
Miki: seeing, *respecting*....
Jess: Yeah, Someone could decorate a room and it could look like a museum of artifacts but the feeling in that space might not jive with the look of it....
Miki: It might not have that *trusting* feeling that it’s okay to try... to take a risk ...
Jess: Or be about feeling that *relationship* between the teacher and students that’s so key...
Miki: So we’re saying that these are key aspects but that it’s more than this...
Jess: And ... It’s more than an add-on
Cynthia: Maybe all it can do is inspire teachers to *action* and ..
Jess: *Commitment* to change things and make a difference
Miki: Where *transformation* is at the centre.

This dialogue is particularly revealing as it captures the group’s synergy - the teachers’ extension and completion of one another’s thoughts and sentences. There is an excitement about the words they chose and the meanings they hold for them. Their words (intentionally italicized): *land*, *organic*, *respecting*, *trusting*, *relationship*, *commitment* and *transformation* describe their understanding of CRE. Transformative and having a commitment to change are key ideas that express the very reasons for becoming culturally responsive mathematics educators. All agreed that the intention of the model was not to develop a “how-to” model for CRE. Instead the model provided a series of ideas that teachers could consider toward becoming culturally responsive teachers.

The model provoked a number of key questions the group continues to explore. How will the model be used to develop lessons for mathematics classrooms? Is there coherence between the proposed model and further classroom practice? Is it possible to use the model to analyze classroom practice for evidence of CRE for others who are learning to be culturally responsive educators? These are questions the group continues to struggle with. A recent question, for example, is the place of mathematics in the model. At the suggestion of Jess the group is considering including six principles of mathematical activity that Bishop (1988) argues are shared by all cultures around the world. These are: counting, measuring, locating, designing, explaining and playing. Both Darren and Jess found Bishop's six principles invaluable, stating that the principles provided "a strategy for keeping my mind on the math and unpacking the math in our cultural events" (Jess, Project meeting October 2009).

Analysis of teachers' "living model of CRE" also reveals their changing views of what CRE is and what it offers. At the beginning of the project teachers mainly described their interest in CRE as curriculum materials that could offer them solutions to their challenges of teaching math to disinterested students. Two years later with opportunities to collaboratively meet, discuss, develop problems, teach and co-teach, teachers describe CRE as moving beyond curriculum materials. Their living model of CRE vividly captures the multidimensionality of CRE and the complex relationships among its components.

Learning from Culturally Responsive Mathematics Education

The previous three sections outlined teachers' initial conceptions of CRE, their explorative practices of CRE during participation in the project, and their living model of CRE in the context of mathematics education. In the following section we examine teachers' learning from involvement in this participatory action research project and how it influenced, and in some cases transformed, their practices.

Validating Cultural Practices

All participants of First Nations ancestry spoke about how the project and its emphasis on culturally responsive education provided opportunities to explore mathematics through the cultural practices of IPL. Jess for example states "I used to think that we didn't use a whole lot of math, we as being IPL, now I think we use lots of math, but we just never called it that." Jess further explained how bringing in a cultural perspective allowed for new ways of seeing things.

It's eye opening, because we don't think of a cedar woven hat as math but there's a tremendous amount of math in that cedar hat we just don't look at things in that way. Or even acknowledge that there is math in that. (Jess Interview, June 2009)

Kuat elaborates on the possibilities the project offered for exploring what she called the "intuitive" mathematics of cultural IPL practices.

I'm an artist and talking with all of the artists and the carpenters and people that create canoes - the intuitive math that it takes to create a canoe is phenomenal. In one of our interviews we talked with an Elder and he talked about how the people of IPL made these canoes that were so perfect that they were only 1/16th of an inch off on either side... they never knew how to read or write....so how did they create these markings to make these perfect vessels? I think it accesses a whole new kind of math that you don't actually get in the formal education system (Project meeting May 2008)

Kuat was fascinated with the mathematics needed to understand the processes of traditional canoe building and navigating as well as weaving. She considered the project as an opportunity to validate cultural practices and “as a segue into the intuitive math” practiced by her ancestors. Referring to many of the museum’s collections of woven hats she notices how “perfect” and “symmetrical” they are. Learning about culturally responsive teaching then:

...teaches you not only about creating a beautiful object, but it teaches you about the math, it teaches you how to be environmentally responsible. It teaches you about integrity. It teaches you about a kind of wholistic kind of feel to it... It's a wholistic approach to what you are looking at.” (Kuat Interview, January 2009).

Learning about CRE for those of Aboriginal ancestry involved validation that cultural practices included mathematical practices. This was also the case for at least one non-Aboriginal participant, Miki. In the spring of 2009 she attended a community totem pole raising event that inspired her. She recalls: “I have always admired totem poles and been amazed by the enormity and baffled by immensity to cut down, carve and erect such a monumental piece.” In describing the mathematics involved in setting the 36 foot long pole in place and then using ropes to upright and turn the pole, she appreciated not only the physical but also the mathematical strength to fall, carve and erect the pole. Reflecting on this she became aware of the importance for her of witnessing, actually being there, to make a personal connection for herself to the culturally practices of the community. This pole raising event emphasized the mathematics embedded in event but it also emphasized for Miki the imperative of personally developing a healthy understanding and experience of IPL cultural knowledge and practices in order for her to teach her students well. This kind of active participation in community events is what Ladson-Billings (1995) refers to as one characteristic of culturally responsive teachers.

Being Responsive to Students

Learning CRE also involved learning to be responsive to students. Two of the 7 participants explicitly mentioned that culturally responsive pedagogy involved focusing on students. For example, Kit stated:

Culturally responsive, the way I see it, is taking what I've learned of the local culture and trying to pull it into the classroom, I know that sounds like a generic answer, but its not just the IPL culture it's the lines of communication. Trying to

keep everyone open and talking and bringing their home life in, or their cultural life into the classroom by using examples, asking them for examples from home...and getting students to bring it. (Interview January 2009)

Culturally responsive education involved being responsive to students, considering students as a resource, attending to their personal knowledge and experiences. However, as articulated in Kit's quote above, teachers also mentioned that culturally responsive education focused on strengthening ways of connecting with and communicating in the community. For Kit, for example, culturally responsive pedagogy required learning more about the local area or local culture. Participation in the project provided the means to develop these connections, knowledge and communications.

Darren too spoke about culturally responsive pedagogy as being responsive to students. He has found that it is an approach that students "really identify with" and requires drawing upon as much localized education as possible to respond to the students' needs and interests. He also spoke about "always being aware of where I am teaching, that I am teaching at home, that I'm teaching students who might be my own relatives, even nieces and nephews." Darren considered his inclusion of culturally responsive mathematics education was improving his teaching as it increased his awareness of making his culture more explicit in his teaching.

It [the project] is making me a better teacher, a more responsible teacher in my approach because I am teaching my own family. I want the kids I teach, especially kids in my family to have the best and the most success that I could possibly give them. I am spending a lot time doing my own art work and practicing my own. The whole culturally responsive aspect is key – I'm living it. (Interview December 2008)

Transforming Views of Mathematics

For Miki, culturally responsive education involved reconceptualizing her views of what counts as mathematics. She commented that culturally responsive education provided opportunities to see mathematics differently, as more than right or wrong and located in places other than the math textbook. These views were articulated below when she stated:

I used to think that math was something you did from a text book, that it was something you did, that it had a right way to do it and a wrong way to do it, and there is a right answer and a wrong answer. And now I think that that is not the case, that math is everywhere, that mathematical opportunities are everywhere, that some questions don't even have an answer. It doesn't matter right - wrong answer. It is just a matter of trying and doing and thinking about it and looking at it. (Miki Interview December 2008)

Carol too refers to how the project transformed her views of mathematics so that she now sees it as everywhere:

I see connections of math even to family and relations. Like math is here and it is everywhere but it does not present itself, you need to dig a little deeper to find the math in the everyday life. But it is there within. This [project] is how it helps me dig deeper within my thinking to see it in places where I have never seen it before.
(Carol, June 2009)

Jess, on the other hand, inspired by Bishop's (1988) principles of mathematical activity, extended her views of math by "unpacking" these principles in IPL practices. She spent two months attending to all the mathematical questions she asked herself as she created an IPL sewing project for her son. Her recognition of the mathematics involved in creating this project transformed her understanding of what counts as math, where it is located, and how she can and has participated in it.

Transforming/decolonizing Views of Self and Culture

Community knowledge holders such as well-known artists, storytellers, Elders, and community organizations such as a local museum were invited to be involved in the research project. The teachers learned about the Indigenous Knowledges (IK) of the IPL through hearing traditional and life experience stories told to them through the one-day meetings and visits to the people's cultural sites. Community artists visited and talked about IPL Knowledge, culture, and values.

During the talks, the community knowledge holders reminded the teachers to appreciate the knowledge expertise of Indigenous people, and to think of math in a very different way as shown in this quote of a well-known community artist.

Last night someone asked if these images tell a story. Boas, [an anthropologist] showed a beautiful box that was probably made around 1890, to [well known early IPL artist] who was a master artist who lived the culture, knew the stories, and Boas asked him what does this [design] mean? So [the artist] recited a Raven story from the box and Boas in his brilliance found the story a bit fanciful. Here is this outsider from New York doubting the [Indigenous] master and also one of the leaders of the culture that breathed and lived culture. So the meaning part; what is math? Like meaning could be made to make math interesting....It is up to us to tell our story, to give it our meaning. For example, when we are fishing, I am cleaning fish and I am putting fish on the rack any old way. My Dad said to put the salmon heading up stream because that ensures the spirit to always come back. So if there is some kind of spirit in math, math is a spiritual being that helps to develop your mind (Project meeting October 2007).

Teachers who were at first hesitant and anxious about including Indigenous Knowledges in their math lessons gradually became more comfortable using this pedagogy through guided project group activities and through hearing stories told by many other Indigenous community members. The following two quotes show one teacher's anxiety and then her openness to a culturally responsive pedagogy after two years of being involved in the project:

I have no problem bringing in examples from my past-like the number of dogs and horses, but I feel really awkward saying the number of [Aboriginal] whatever – like differentiating between [Aboriginal] and non[Aboriginal]. Or talking about something that I feel I have no right to talk about. If we are talking about [First Nations art shapes] that’s different. I’m uncomfortable. Some of the kids look at you – and no one has even said anything to me – but I think in the back of my mind they look at you and think, ‘Who is she to be talking about this?’ I look at [Aboriginal] culture as a belief system – like a religion. You don’t want to offend anyone so you just don’t touch it (Kit, Project meeting September 2007).

[Two years later]. In response to the question, “I used to thinkand now I think.....”

Kit states:

The first thing that popped into my head was I used to think [Indigenous] culture was scary and something I couldn’t touch and wasn’t allowed to talk about...now I think...I can talk about [it] as long as I’m respectful. [Before] I was afraid of offending somebody...now I realize that it is something that you can talk about and you can learn from the students because they want to tell you about it, they want to tell you what they know, and they want to share it with you, and its Ok if you make a mistake, they will correct you and laugh at you [in a good way]. That’s Ok, So, I’m not afraid of talking about [Indigenous culture], of bringing it into the classroom anymore (Interview January 2009).

Other project teachers discussed how learning about CRE has helped them attend to decolonizing their own views of themselves as teachers. Carol’s comments speak to her awareness and challenge of teaching students who are different from herself:

These meetings have made me think about relevance and connection. I didn’t grow up in this beautiful area. I grew up in the suburbs as a non-Aboriginal person. I think that I constantly need reminding of this. This place offers connections to the land and nature that is so part of IPL culture....I need continued reminding that my background and learning may be different from my students. I have to remember that my students, my children are coming from a different perspective. (Carol Interview June 2009)

These comments are significant. Dion (2009) refers to the ‘perfect stranger’ stance as a coping mechanism of most non-Aboriginal Canadian teachers: they mean to do well but they endlessly claim no knowledge, no relation or connection to Aboriginal peoples (Dion, 2009, pp.179-181). In this way, non-Aboriginal teachers regularly abdicate any responsibility in actively knowing or discriminating against Aboriginal peoples and students. However as can be seen in the comments of Kit and Carol their ‘perfect stranger’ stance had shifted somewhat with their involvement in the project. Carol’s words highlight this shift further:

I do think there is always more to learn about the culture. I could learn more about the language and that shows respect ... but I have to be careful... Sometimes I stereotype to income and lifestyle correlation ... I put on those stereotypical hats .. So I need to

catch myself when I make those judgments because I think I do [make judgments], even though I say I don't (Interview June 2009)

Carol's reflection also speaks to the importance of teachers knowing who they are as culturally and historically-located people. Battiste (2004) argues that it is almost impossible for non-Aboriginal teachers to decolonize themselves and recognize the cultural resilience of Aboriginal students in classrooms until they first grapple with their own cultural locations and positionality. Teachers in this project show evidence of such examination of their cultural identity.

Bridging Culture and Mathematics

For some participants culturally responsive mathematics education was seen as a bridge between two worlds of culture and mathematics. 'How can we bring the culture into the math lesson?' asks Miki. For Miki and Maria bringing and using objects that are located in the community rather than outside the community to teach mathematics were key. Miki explained further with an example that her upcoming lessons for her primary students on shapes in mathematics will include shapes familiar and prominent to IPL art:

I'm looking at covering shapes in the new year and including the shapes that are important to IPL art and to IPL people, which you don't find in a math book. The two dimensional, three dimensional shapes in a math IRP [provincial curriculum] doesn't include an ovoid and a "U" shape and those sort of things. So finding those shapes and seeing if we can find an ovoid in the natural environment. Because all of those shapes exist in our natural environment. (Miki interview June 2009)

Miki further suggested activities such as inviting students to participate in a "shape walk" where students could walk outside to the playground or beach and search for the ovoid and "U" shapes so prominent in IPL art. She suggested students draw, talk and compare these shapes to ones that are less organic such as squares and rectangles, while comparing the similarities and differences between them. This way of thinking about teaching is new for Miki and she attributes it to her participation in the project.

I think beforehand I probably wouldn't even have thought to incorporate the shapes found in IPL art forms. It's not something where the idea is out there. Where now I'm questioning for myself, how I can bring in culture into lessons. (Miki interview June 2009)

Similarly, Kit describes students views about the worlds of math and culture as "two separate worlds, ... in the students' mind they never seemed to link them together." She states that there is typically "zero link in the classroom between the students and learning math and what was around them." For Kit culturally responsive education provided ways of pulling from the local culture and bringing it to the classroom to make it relevant "rather than bringing in some weird numbers on paper that somebody in a far distant land has made us learn." Kit describes one of her math lessons

I actually did one lesson where I took a very simple IPL drawing, a black and white drawing, and then I put it over top of a grid for graphing. Students could actually shade it in and do the area and they could move the ovoid up and see how the ratio changed, and how aesthetically different it looked, and the students were saying, 'Oh no you have to put it back down again,' and we would explain ... we could see mathematically why because of the ratios. (Kit December 2008)

As the project progressed Miki changed her understanding of the relationship of mathematics and culture. Instead of a 'bridging' metaphor, Miki took to heart Archibald's (2008) storywork methodology. She questioned how it could be possible to have one-off CRE lessons when: "Nothing is separate or segregated, it's interrelatedness, it's all that bigger picture. It's all woven together ... wholistic." She explains further that "it's not possible to say 'I've tied this back to the culture' without practicing qualities in the classroom that are important" (Interview June 2009). For Miki, her changing views of CRE illustrate her ongoing efforts of becoming a culturally responsive educator, and that this work is not a linear but a more organic growing process. However, not all teachers were able to sustain their practice of CRE across mathematical topics or throughout the school year. Although Kit spoke about implementing lessons that connected math, community and culture, she also mentioned that these lessons were peppered throughout her course and in between textbook activities. Maria also struggled between her desire to implement more inquiry and problem solving that required a different kind of relationship between she and her students, and her felt need to keep the class managed and on task. As Maria stated: I really do want to do more problem solving but my students just won't let me...they're much better with worksheets and structure... so I'm trying to figure out how to do both" (Project meeting February 2009). As a result Maria developed CRE lessons that were explicitly tied to her students' mathematics workbooks. A lesson on multiplication was altered to use traditional IPL forms of currency, where the context was as, Jess noticed "more superficial" than "an intricate aspect of the problem" (Project meeting June 2009).

Learning from Each Other

At project meetings teachers shared their experiences through telling their stories, showing samples of student work, showing photographs, and video teaching episodes. Four members of the group have been involved for three years and one member for two years. They have developed a comfortable relationship with each other and with the university researchers and community knowledge holders. There is trust and a willingness to talk about problems and successes. As each person shares her and his experiences, a space is created to listen to each other, to engage in a dialogic action where they respond to each other's questions and concerns and a synergistic action happens where new understandings are created. The group members also drew upon each other's knowledge and experience to extend their own understanding of IPL ways of knowing. The following quotes show the benefits of the discussion sessions in response to the question about what has stood out so far about the project:

... sharing of information and the sharing of experiences that people have had within our little group (Maria Interview June 2009).

The most beneficial thing? ...there are so many things. To brainstorm ideas in terms of somebody will say something and that spurs a thought that I wouldn't have had on my own, or that kind of thing. As well as just to go away and try something and come back and see how different people approached it and what that looked like in different scenarios. And just meeting to discuss lessons and kids and math (Kit Interview January 2009).

The neat thing I found was getting together with the colleagues at different grade levels or different teaching and seeing what they deal with because sometimes any teacher can get in their own [self-contained classroom]. I mean you talk to someone who teaches your same grade level, but to deal with what ...their issues are in mathematics and we try to take the same thing and take it back to our classroom and have our students do it, but we have to adapt to the different age level, so that is really fascinating to see that how its done at different grade levels and show share how we adapt it (Carol Interview June 2009).

The group diversity of different grade level teachers, non-Aboriginal and Aboriginal teachers, new and seasoned teachers, and different schools are beneficial in a number of ways. Teacher participants gain an understanding of students' math learning that happens before and after their particular teaching level. They either gain cultural understandings from those who shared it or had the importance of cultural knowledge reinforced by group members who experienced positive results from using IK in their math lessons. The district Aboriginal Education principal noted the positive effect of the group sessions: "When I was working in the school a couple of my teachers were involved in the project. They would come back to work as if they'd been off on a holiday, and yet it wasn't a holiday. I knew they were working" (Jess Interview December 2008).

Teaching in a rural school district is demanding. There are few opportunities for professional development. In this district teachers can access district professional development funding to attend a professional conference in the city-centre once every two to three years. Professional development within the IPL area in specific subject areas is limited. In addition, geographic distances between the north and south schools in IPL make it a challenge to bring teachers from different schools together even for short meetings. Thus teachers' comments pointing to the value placed on working with colleagues and community members are understandable.

Learning About Students in Culturally Responsive Mathematics Education

Teachers' understanding and interpretation of students' experience in CRE is important. How teachers consider students' engagement, the extent to which they are aware of students' experiences, and what they attend to provide insight into teachers' CRE practices. Formal assessment of student achievement is beyond the scope of this report.

Nonetheless what teachers say about their students' work with CRE highlights what teachers find important.

All teachers in the project stated student responses to their culturally responsive lessons were well received. This doesn't imply that all lessons were a success, but for the most part, teachers' perceived their CRE work was making a difference for some students. Darren, for example stated that culturally responsive education challenged his assumptions and views of student expertise in the classroom. Struggling students may feel confident to engage or comment on lessons that are drawn upon contexts that are familiar. Darren stated he noticed that culturally responsive education...

...really allows learners that might be labelled as a struggling to all of a sudden, in some cases, become an expert on a certain subject area. Students then feel the confidence to be able to speak to that lesson and speak to that issue, where normally they would just happily be just kind of quiet and kind of not ready to participate. So it [culturally responsive education] kind of opens up a whole new dialogue for students who never really would participate in the traditional type of learning (Interview December 2008)

Darren provided multiple examples of students in his class who were typically less engaged in the mathematical conversations but who showed great interest in math when the concepts were taught through familiar and local examples. One student for example who rarely shared his thinking in class became the class expert on crab traps and readily offered information that others did not know about crab fishing.

Miki and Kit commented that student engagement and interest was high when they taught culturally responsive lessons. Miki describes students' engagement in her beach pattern lessons:

They [students] were able to work together ... there was synergy ... Some of them found their materials together and worked together... But they ultimately each chose one material ... there was a give and take in their partnerships and their building part too ... they were communicating." (Miki interview June 2009)

Teachers also articulated tensions and challenges of teaching as culturally responsive pedagogy. Some expressed concern that introducing culturally responsive lessons drew attention to the use of time. Kit, for example, worried whether or not the lessons were the best use of time, whether or not students were learning something that would at the same time prepare them for the provincial final exam. In a course where time is a constraint, deviating from the textbook developed lessons can be a costly action.

Others such as Maria stated that she would like to bring in more of the culturally responsive lessons but "it feels like it takes a lot of energy." She felt comfortable teaching lessons that she and the project group developed but felt she couldn't go beyond that. "I am struggling on looking for it on my own." Maria also spoke about the importance of the synergy in the group meetings and how it inspired her to keep working at developing

culturally responsive teaching practices. But that this inspiration needed constant support to keep it “from dying off after a little while.”

Still others such as Miki felt the challenge of CRE was in finding ways to learn more about IPL culture and practices, and that such work was left to the individual. Although she recognized that her way of thinking about CRE had changed “so that it’s easier for me, at this point, to look at something and say how can I make this culturally responsive” she still found it a challenge to access materials that would, for example, help her learn the IPL language.

A further challenge lies in providing support to allow the project to become self-sustaining. We wonder how to continue the momentum, the synergy that the participants experience in the group sessions, after the research project funding is completed. We are concerned that most of the study participants note a heavy reliance upon the university researchers to keep the “project” going as noted in the December 2008 interviews: “I think we’re becoming somewhat dependent on her being there, for her expertise, for her making us do tasks and keeping us motivated.” They acknowledge the important mentoring and coordinating roles she has played. At the same time, they also acknowledge their appreciation of school district that allows them to attend the group meetings, the project funding that provides their release time, and their appreciation of Indigenous community support for sharing their cultural knowledge and for using their on-site facilities for group meetings. It should be noted that the district will support teachers with release time to attend further meetings and a new theme of the district over the next five years will be culturally responsive education for all teachers. It will be interesting see how the project develops with increased support at this district level.

Validating Living CRE through Mobilizing Knowledge

During the past two years of the project teachers and community members have had opportunities to share their growing understanding and actualization of CRE. In true spirit of reciprocity and respect, project teaches have shared their work on the project with their colleagues during school staff meetings, district professional development days and community meetings. All project teachers presented their work at two provincial conferences and with doctoral students in a UBC course on Indigenous Knowledges. In addition two of the project teachers presented at a national conference. We have collaborated on a number of papers and together are working on an edited book where each teacher will contribute a chapter describing and analyzing CRE in his/her mathematics classrooms. Before these opportunities none of the project teachers had participated as a conference speaker. Teachers found the experience of standing before colleagues at local, provincial and national levels to share their developing understandings of CRE as transformative.

Preparing for the presentations took days of collaboration in deciding what story to tell the audience, how to engage the audience in exploring the nature of CRE in their own communities, and how to share the tasks so that all were involved. The group treated the

experience as a continuation of CRE and considered the presentation an opportunity to give back to the communities. After each presentation the group gathered written or oral feedback from the audience that formed the substance of the group's post-presentation debriefing sessions.

Project teachers recognized the value of the project for themselves and their colleagues but they did not anticipate the value placed on it from others. For example, doctoral students in the UBC Indigenous Knowledges course stated their appreciation to teachers in sharing their work connecting mathematics to the land through images. A sample of comments, representative of comments collected at all presentations follows:

- It's been really inspiring and energizing to hear what other districts are doing. And it puts pieces together in a different way that I hadn't thought about before. I think a huge piece is that these images really bridge worldviews. And we talked in our class that if you open the door to Indigenous Knowledges, whether it be in science or math or any other area, to open that door to Indigenous Knowledges is through imagery. ...I think that's where there is a really open space - where non-Aboriginal educators can connect to the land and can gain some understanding, and within a community it connects with the language. So many kids in the community are disconnected with the language and those images provide a common story. So for me it was really a significant observation. So I encourage you to keep working in this area. (Doctoral student in the UBC Indigenous Knowledges course)
- I really think we've witnessed the best of collaborative work between Indigenous and non-Indigenous educators. I really appreciate that. My hands up to you. You're doing revolutionary work and I'm very pleased to witness it. Thank you. (Doctoral student in the UBC Indigenous Knowledges course)
- Your work is so inspiring, so powerful. I'm deeply moved by your efforts. (Member of the audience at provincial conference 2008)
- I'm starting to really think about how this could be used in all Aboriginal communities. Your students aren't removed from what they're learning and I think that can be applied to lots of different learning. And also that students were involved in the process all the way through so that they see themselves in the work – it's not that math is here and there...but that it is a part of us. (Member of the audience at national conference 2009)

Group discussions about this kind of feedback encouraged teachers to not only continue their work but to also recognize the extended value of it. Although they understood the value for themselves and their community, they did not expect that others outside IPL would also see such value. The group's discussion following a provincial presentation highlights the teachers' shift in understanding about the impact of their work:

Miki: I had no idea people would respond in that way. They actually called our work revolutionary. Can you believe it?.

Darren: I'm amazed.... It was really interesting that they could see how they could take these ideas and apply it to their own culture and community. I hadn't thought about it like that before.

Jess: It's so powerful....

Darren: ... I still can't believe the reaction... That people are really interested in what we're doing.

Maria: We even had people ask to buy our book [math photobook]. (Project meeting October 2008)

Sharing their understanding of CRE in the context of mathematics education has motivated the teachers to continue their work, to recognize the importance of mobilizing their learning, and the importance of giving back to the community. Living CRE included sharing their understanding with others and that in turn seemed to validate the importance of their work for others. Such validation was an important aspect of the project.

However, not all project teachers embraced sharing more publicly their understanding, experience and knowledge of CRE gained through the project. Kit was so fearful of presenting before her colleagues that she was unable to participate in this part of the project. Her fear of public speaking was too great and although she received a great deal of support and encouragement from the group and other colleagues she decided in the end that she could not perform. In an e-mail to the group Kit wrote:

I don't think that i can make it. ... I really don't like presenting. :(I love being part of the brainstorming and development team but I have a serious fear of public speaking. Ironic with me being a teacher but it is true. (e-mail Oct 2008)

From Being Researched to Being Culturally Responsive Researchers

During a project meeting in the third year Jess spoke about an incident that deeply affected her. She had recently seen photos of a researcher she knew giving a presentation at his university on IPL culture. Jess shared her disbelief. She couldn't understand how such a presentation could occur without the permission and acknowledgement of the people of IPL. Her anger was felt by the group when she stated that the "researchers benefit, but then there is nothing left" for the people. Jess was familiar with the work of this researcher and had previous experience with his project.

Jess: It's just sort of taken for granted [that people will participate]. It's just taken and ... that whole reciprocity thing ... it is so important. And I think what makes this [TEAM-Learning project] so successful here is that we give, and we take, and we give. We have a balance.

Carol and Miki: It's kind of a respect thing.

Jess: It's a huge respect thing. And so much of what they [the other researchers] said during their time at IPL was about being respectful and this [experience with the other researchers' project on IPL] was the most awful experience I think I've ever had of my life with educated people. .. To be treated so poorly. (Project meeting June 2009)

The group discussed with Jess possible responses such as writing a letter to the researchers to let them know how she felt. The teachers talked about the power of research and what it felt like to be researched. They recalled a previous story told by Jess to the group about her mother's experience with researchers. Jess' mother felt researchers were "always wanting us to share something, to give something..." The effect, noted the group, was a distrust and distain for any kind of research including, suggested Jess, research by family members.

Carol: [to Jess] Didn't you say that about your Mother [in a previous meeting]. She said 'No more. I don't want to be researched.' I'll never forget that.

Jess: Yeah, even when my son wanted to interview her for one of his elementary school projects... She said No.... And it only takes one bad experience with a research project ... That's why old people will sometimes look at you and go - Nope [when asked to participate in research projects]. (Project meeting June 2009)

Participation for Jess and other project teachers in the TEAM-Learning project helped move their experiences and understandings of research from being researched *on* to being teacher researchers and research collaborators. As the project progressed they began to see themselves more as co-researchers taking on the tasks of inquiring into their practices as they lived CRE in their classrooms. However seeing themselves as co-researchers and acting as co-researchers took time. At the end of the third year of the project Miki's comments are representative of others in reflecting on how she now feels about researching her own classroom:

I feel as if I'm just getting it now. To take pictures and get the students' responses. It has taken me three years. But I'm getting it. I can feel that ... There's not so much - 'Oh shoot I forgot to pull out my camera' after it's happened. It's that internalization. Three years down the road. It's not overnight. It is years. It is years. (Miki, Project meeting June 2009)

The opportunity to learn together, to develop a learning community, to share ideas and investigate possibilities was key. The lack of such opportunity, noted Jess, was why many teachers stated they decided to leave IPL "On their exit slips, they said they didn't have that sense of learning community... that was one reason why they left." And for Miki, being part of the project learning community is one reason why she has chosen to stay in IPL.

...That first meeting we had [three years ago]. I think I still wasn't sure what I'd be doing, to stay [in IPL] or not ... One of the things that made me stay is that I felt committed to this math group. I'm involved in this group and I'm committed to it. I have to see things through. It's that commitment piece. It's a reason to - you can't force anyone. But it could be a reason to stay. ... (Project meeting June 2009)

These findings have outlined teachers' initial conceptions of CRE, their explorative practices of CRE during participation in the project, their living model of CRE in the

context of mathematics education, and what teachers learn from involvement in this project, as well as how it influenced, and in some cases transformed, their practices.

Culturally Responsive Education as a Way of Being

Although the project provided opportunities for teachers to examine their cultural assumptions and to practice CRE within the group meetings and in their classrooms it also emphasized the need for continued learning. Teachers spoke about their desire to deepen their understanding and experience with IPL culture and values. This can be seen through Miki's comment at a group project meeting:

I've been here 5 years now. I don't have any IPL language. I think that's pathetic on my part, but I don't have the energy and time to pursue this on my own. I need to be taught. (Project meeting January 2010)

The group explored ideas for how they could learn IPL language, and strategies for how such learning and teaching could be part of their school's professional development. This is a great challenge for communities such as IPL that have devoted funds, time and energy for language development for Elders and youth within the community. To commit further time and resources to teach members outside the community is another layered commitment. Yet as Jess eloquently suggests:

Teachers and Elders need to learn how to dance together. It will take years for students to learn how to give a speech in IPL language at a feast or potlatch. (Project meeting January 2010).

Learning some IPL language Miki states would allow her to continue learning about IPL culture placing her in a better position to connect with her students and their families as well as possibly bring in some math through everyday activities such as counting and calendar work. However there are few resources to support teachers who might want to learn the language and Elders available to provide some assistance.

Learning the IPL language is a significant aspect of becoming a culturally responsive educator for both Aboriginal and non-Aboriginal IPL teachers. However it isn't necessarily the place to start. Jess contributes her thoughts on this issue of what is needed to teach as culturally responsive educators with the following comments shared at a project meeting:

I think teachers really need to have a good idea about what culturally responsive education is and isn't. We have totems, books, language rooms, but is there anything else beyond and set in place? Culturally responsive education is more than window dressing... it's a way of being for the teacher. And the teacher doesn't need to know all that culture, but just to be able to give it equal space and time. (Project meeting January 2010)

Jess further continued that a culturally responsive classroom would

.... feel like the kids are actively participating. It's a trusting relationship....It's more the feeling than seeing. Someone could decorate a room and it could look like a museum of artifacts but the feeling in the space might not jive with the look of it. (Project meeting January 2010).

Jess's comments resonated with the group: culturally responsive education needed to be lived; it needed to be an integral part of teaching. It was something not necessarily found in resources, although resources, the teachers noted were important. Instead, learning to be a culturally responsive educator required as Miki stated "the ownership of doing." It requires ongoing practice and experience as well as opportunities to share ideas and learn from each other.

Discussion and Conclusions

The methodological use of Indigenous storywork principles of respect, responsibility, reverence, and reciprocity created a shared space for bringing together students' thinking/learning, Indigenous culture and community, and mathematics. The research team demonstrated respect toward Indigenous peoples, Indigenous Knowledges, and non-Indigenous peoples at the research site by first taking the time necessary to develop positive interpersonal relationships with teachers, school administrators, and community members and second, exercising care in learning about the cultural and community context for each site. It took at least one year to develop trust and working relationships with teachers at the sites. When possible, researchers attended community cultural events and meetings. Responsibility was demonstrated by acquiring ethical approval of the community-based Indigenous educational council, the public school district and the university to conduct the research. Reverence was practiced by learning about how to understand and use Indigenous knowledge that did not disrespect cultural protocols or community ethics and that did not essentialize or appropriate IK. For example, local Indigenous stories were used with permission by the applicable community member/organization. Community cultural knowledge holders shared their wholistic Indigenous Knowledges with teachers and researchers to help teachers better understand cultural knowledge, their stories, and local values, teachings and Aboriginal languages. TEAM-Learning projects, which became a form of reciprocity, were cooperatively agreed upon by the participating teachers and researchers. They included curriculum units and multi-media learning resources. These learning materials will be left with the schools and school district so that other teachers can use them in the future.

Teachers' knowledge and understanding of culturally responsive pedagogy was enriched through their TEAM-Learning experiences. The storywork principles of wholism, inter-relatedness, and synergy helped them explore and share their evolving understandings in the regularly scheduled group meetings. During the research process teachers gathered to share their classroom experiences, to talk about their anxieties about teaching math or using Indigenous culture, to cooperatively plan their projects, and to discuss what they

learned about bringing together students' math learning, their community context, and their culture. The researchers and teachers listened, asked questions, and gave suggestions. Storywork encourages participants to engage holistically – addressing the intellectual, emotional, spiritual, and physical realms of our humanness. Often, teachers do not get the chance to talk with their school colleagues in a manner that is holistic nor do they talk across grade levels. TEAM-Learning sessions brought primary grade and high school teachers together to create a shared knowledge about the inter-related connections between math, community, and culture. Teachers' enthusiasm and feelings of frustration created a synergistic action that brought culturally responsive pedagogy to life for them, their students, and the community.

During 2008-09, the study participants presented aspects of the TEAM-Learning project at a school district professional development workshop, a university graduate education class, a provincial math conference, national Indigenous math and science conference, and to their local schools. These presentations helped them to articulate the relationship between culturally responsive educational principles and the applied nature of their math projects. The undergraduate UBC course related to the project and held in IPL had a service learning and reciprocity component where the learners developed a culturally responsive education and math project that would be useful to a school or community group. The study participants who enrolled in this course had further opportunities to deepen their understandings of Indigenous Knowledges in relation to culturally responsive education. Through these types of presentations, the teachers received positive reinforcement about their culturally responsive pedagogy and most importantly they re-imagined their role and relationship to mathematics, to their students, and to themselves.

The TEAM-Learning university researchers will need to address the concern of how to lessen the mentoring dependence on the principal researcher and transfer that role to the participating teachers. The various presentations and new projects as noted above, and the group meetings, help the teacher participants re-imagine their role or help them look at their culturally responsive approaches from new perspectives. The Indigenous story of Raven, a trickster figure, started a synergistic storywork action that has transformative possibilities for improving Aboriginal math teaching and learning. We look forward to encountering the next story on our journey. Our project continues with a particular focus on student learning in classrooms with project teachers.

Major findings drawn particularly from the case of Indigenous Peoples of the Lands or IPL follow. Findings are linked to the research questions. As a case study these findings should not be interpreted as generalizable to a larger population. Instead these data indicate that it is possible to construct culturally responsive mathematics education practices that are transformative for teachers.

- 1) What are IPL teachers' initial perceptions and experiences of culturally responsive mathematics education?
 - Both Aboriginal and non-Aboriginal IPL mathematics teachers at the elementary and secondary level reported that they did not consider culture, Indigenous Knowledges or community when planning, teaching and assessing mathematics.

Culturally responsive teaching practices were considered by teachers to be separate from the world of mathematics teaching and learning. Teachers were keen to learn more about how they could improve their mathematics teaching, make it more relevant for their students, and learn more about IPL cultural values.

- 2) As IPL teachers participate in the project how do they practice culturally responsive education and what does it mean to them?
- Teachers practiced CRE through multiple levels. They practiced CRE during research project group meetings, through collective group projects, and through individual projects. They made connections with community knowledge holders, Elders, and artists during project meetings and these connections extended to their classrooms. The practice of CRE can be seen in the multiple lessons and books the project team has presented to and developed for the community (see Appendix E for a list of these materials).
 - Practicing CRE involved Aboriginal and non-Aboriginal teachers' perspectives, beliefs and practices shifting toward culturally responsive curriculum and pedagogy. Teachers considered these shifts as transformative. Teachers who once considered themselves as strangers to the culture and values of Indigenous Peoples of the Lands (IPL) at the beginning of the project, were actively developing and teaching culturally responsive mathematics lessons by the end of the project.
 - All teachers in the project developed perspectives that included culturally responsive education practices in mathematics education as evidenced by their ability to pose inquiry-based mathematics problems that connected their students to the place, language and culture of IPL. However, some teachers were more able to sustain this perspective across mathematics topics throughout the year, whereas others were able to practice CRE more through implementing certain lessons that were interspersed between textbook work.
 - Developing culturally responsive approaches to mathematics education involved teachers in transforming their views about the nature of mathematics, who can do mathematics, where mathematics lies (e.g. in IPL art, stories, carving and canoe building), and how culture and mathematics are and can be inter-related.
 - Culturally responsive educational practices offer opportunities for non-Aboriginal teachers to decolonize themselves through learning about Indigenous Knowledges and epistemologies. CRE offers Aboriginal teachers opportunities to explore strategies and possibilities for CRE curriculum development and pedagogy.
 - IPL teachers recognize that developing culturally responsive practices requires time and extensive continued professional development over several years (not days or weeks) that involve community members and teachers.
 - Teachers can develop their own living model of CRE that is grounded in the context or setting in which they live and work. For IPL teachers their living model of CRE included the key aspects: place, action, inquiry, relationships and storywork.

- Opportunities to mobilize or share their knowledge, experience and understanding of CRE to various audiences motivated, validated and inspired IPL teachers to continue exploring the nature of CRE in their classrooms.
- 3) How can participatory action research and Indigenous storywork methodology be potential tools for professional development in the context of mathematics education?
- Indigenous storywork methodology and participatory action research supported teachers as they critically considered their own practice of mathematics teaching, considered alternatives such as CRE, and lived CRE by deciding on and practicing CRE within the context of the research group and their own classrooms.
 - Using participatory action research and Indigenous storywork methodology for the development of culturally responsive mathematics education involves: 1) establishing relationships through university and community protocols, frequent visiting and meeting, and being active participants in the community; 2) learning about Indigenous Knowledges through experiencing Indigenous stories shared by local community members; and 3) learning from each other through personal stories and mentoring providing opportunities for creating synergy, a key aspect of Indigenous storywork.
 - Participatory action research and Indigenous storywork methodology are promising frameworks for culturally responsive education research and pedagogy. These methodologies provide teachers with opportunities to work together, examine issues critically from a variety of perspectives, listen to alternative arguments and rationales, share solutions and ideas to common problems, learn from each other's practice. Nonetheless it was recognized that time and multiple opportunities to explore community, local culture and values are needed for Aboriginal and non-Aboriginal teachers to draw upon the methodology to inform their own mathematics teaching practice.
 - Participatory action research and Indigenous storywork methodology provided opportunities for teachers to transform their views of mathematics and examine their own cultural identities; validate cultural practices from a mathematical perspective, and learn to be responsive to students' cultural backgrounds.
 - Teachers noticed that students benefit from culturally responsive lessons. Teachers report increased engagement and participation by students, particularly those students who had lost their interest and confidence in school mathematics.

Implications for Culturally Responsive Education and Professional Development

Drawing upon our findings on what culturally responsive education might look like in IPL we offer these fundamental recommendations for further research and professional development in this area.

- 1) Teachers can develop living models of CRE and these can provide a structure for teachers to select, adapt, and prepare culturally responsive lessons.

It can be used together with existing mathematics curriculum to explore mathematics in contexts that are compelling to students and educators. Although teachers considered CRE to be more than a series of lessons, the Living Model of CRE can be a starting point for educators to ask themselves questions about their lessons: How will my lesson help students learn more about this place? How does it help us build relationships? How might the lesson inspire students to action? What kinds of problems does my lesson explore and how does it draw upon stories? Not all these questions need to be answered in one lesson but the model can be considered as a reflective tool for teachers who are interested and committed to becoming culturally responsive mathematics teachers.

- 2) Working toward CRE approaches to mathematics education must be collaborative involving effort and contributions among teachers, parents, community and students as well as educational researchers.
- 3) Teachers should be encouraged and given opportunities to work with communities for culturally responsive education. Thus, professional development opportunities on CRE should be increased.
- 4) Teachers should be provided with opportunities to engage in developing, practicing, evaluating and living CRE.
- 5) Teachers should be encouraged by Districts to mobilize or share their knowledge, experience and understanding of CRE as this can motivate, validate and inspire teachers to continue exploring the nature of CRE in their classrooms.

This research project contributes to the literature calling for educational practices that are culturally responsive. Such practices have held promise for improving mathematics teaching and learning at the elementary and secondary school levels. Our findings provide much needed examples of how culturally responsive mathematics education can be enacted and lived in a rural context. Teachers and community members working together exploring how to draw upon students' interests, backgrounds, and identities as resources for creating meaningful educational experiences can conceptualize the possibilities of culturally responsive education. Our findings indicate that developing culturally responsive practices requires years of sustained and connected professional development. Professional development that involves teachers in thinking about culturally responsive education once or twice over one year is not enough. It takes time to develop an approach to curriculum and pedagogy that connects mathematics, culture and community. Regular meetings for teachers to question, explore, and examine their teaching in a collaborative and collective space is key. The results of our study provide empirical evidence of Pewewardy and Hammer's (2003) statement that culturally responsive education for Indigenous students "relies on the development of certain dispositions toward learners and a holistic approach to curriculum and instruction."

- 6) Respecting, recognizing and valuing teachers' and community members' time and contributions toward CRE are key to sustaining the life of a participatory action research project.
- 7) Professional development opportunities for CRE should be conceptualized as an organic, wholistic and inter-related process that takes time rather than as an accumulation of steps and skills.
- 8) Participatory action research together with Indigenous storywork methodology effectively combines theory and practice in respectful and reciprocal ways. Together these methods provide a coherent strategy for exploring, creating and sustaining CRE practices.

Increasing opportunities for professional development is important, however it is also important to consider these opportunities not as interventions or “in-service” where teachers need to be fixed, but instead as an ecological process. Participatory action research and Indigenous storywork methodology provide a framework for considering not only how teachers might develop culturally responsive mathematics education but also how professional development opportunities might be constructed. Conceptualizing culturally responsive education for students involves living similar practices as teachers and teacher educators. This will involve considering the seven principles of Indigenous storywork in creating and enacting professional development opportunities.

- 9) A number of important considerations in bringing participatory action research and Indigenous storywork methodology together appear to contribute to the healthy exploration of CRE. These include: structuring the group with questions, activities, and ideas from teachers and community members; encouraging diversity in group composition (eg. across schools and grade levels – elementary and secondary levels – administration and teachers and community members); motivation (this work takes time and energy and requires recognition of those involved); group facilitator(s) who is connected to the schools and community).
- 10) CRE approaches to teaching can be extended to professional development.
- 11) CRE approaches can involve all teachers, Aboriginal and non-Aboriginal in continued efforts to raise consciousness and practices that are culturally responsive.

Luitel and Taylor (2007) described the importance of taking hold of efforts to connect mathematics, students, community and culture for all students. They state:

if we are to promote cultural and linguistic diversity within a philosophy of ‘education for all,’ then no country can afford to have its indigenous cultures ignored, displaced or replaced ... mathematics education, at all levels, should be a vehicle for promoting both local and global culture.” (p. 624)

The consciousness of educators, parents, students, community members and researchers around issues of developing culturally responsive and inclusive mathematics education must continue to be raised. This requires the collective effort of members within the

community and outside, both Aboriginal and non-Aboriginal. Our project provides an example of how this might be conceptualized within a rural school district and its findings have made a significant impact locally, nationally, and internationally. Locally the project has garnered so much interest and support that community members and teachers requested a university level course that explores issues of Indigenous Knowledges, community-based mathematics education and practices of culturally responsive mathematics education. This course is currently being offered with 15 teachers and community members enrolled. The project has provided the community with a number of lessons and books that can be used in classrooms (the district has agreed to cover the cost of publishing and distributing the materials). The project has sparked national interest through invitations to present at the 2009 National DreamCatching conference, the 2009 Canadian Mathematics Forum, and the 2009 Canadian Mathematics Educators Study Group. We have had requests from teachers and researchers across Canada and internationally for access to materials developed by project teachers. International impact of project findings is evidenced by an invitation to edit a book on culturally responsive mathematics education for Indigenous students (Sense Publishing). We are also currently working on establishing an international network for culturally responsive mathematics education for and with Indigenous communities.

The project findings provide a community-based model for developing culturally responsive approaches to mathematics teaching that draws upon and is rooted in Indigenous Knowledges and Indigenous storywork methodology. This model could be used by the district to inform policy and decisions for the development of the district's Aboriginal Enhancement Agreement and curriculum innovations. The model could also be used by the local museum in its development of educational resources. Outside IPL, the model could also be used by other school districts in the province and the country. However, although the development of the model through PAR and storywork methodologies are promising, it by itself is far from sufficient to develop a professional culture at a school level which welcomes CRE, in which inquiry into CRE is practiced—and if found useful—are transformed for everyday practice. For this to happen schools need support, resources and structures that provide the context, reason, legitimacy and inspiration to examine and live CRE.

Our project provides a perspective on the education of Aboriginal students in mathematics. Studying how teachers become aware of and use Aboriginal students' culture, experiences, and mathematical thinking to develop instruction helps us understand the nature and impact of culturally responsive practices. The case of teachers in Aboriginal communities provides further insight into the nature of culturally responsive teaching practices that may be applicable to all students. Such practices challenge the concept of uniformity and neutrality of knowledge creation processes and advocate for pedagogy of multiple discourses. Our study highlights Aboriginal and non-Aboriginal teachers' beginning questions and insights as they explore how their classrooms might be sites that privilege certain voices and discourses. However, the study also raises questions around how culturally responsive practices honor particular local communities and cultures without trivializing, generalizing, or stereotyping learning across diverse groups and locations. Nonetheless, this study contributes valuable

information for policy recommendations about teachers' professional development related to Aboriginal and mathematics education. Given there is such little knowledge in mathematics education for Aboriginal education, this study uniquely contributes to our growing understanding of mathematics education, teacher education, Aboriginal education, and how we can develop respectful research relationships with Aboriginal communities.

The educational significance of our research, which is in stages of data analysis, focuses on how teachers become aware of and responsive to Indigenous ways of knowing, students' culture and experiences, and mathematical thinking to develop their own curriculum and instruction. Such practices challenge the concept of uniformity and neutrality of knowledge creation processes and advocate for a pedagogy of multiple discourses that connects disciplines of mathematics education, teacher education, and Indigenous Knowledges and ways of knowing.

Acknowledgements

This research would not be possible without the dedication, heart, and honesty of the IPL school district, administrators, teachers, students and community members of IPL. We would like to thank all the teachers, students and community members who participated in the project. We also thank the numerous graduate students who were members of TEAM-Learning and assisted with data collection and analysis procedures. We acknowledge the Vancouver Foundation, the Canadian Council on Learning, and the Social Sciences and Humanities Research Council who contributed funding toward this project. Hawaa.

References

- Aguilera, D. Lipka, J. Demmert, W. Tippeconnic, J. (2007). Special issue on culturally responsive education for American Indian, Alaska Native and Native Hawaiian Students. *Journal of American Indian Education*, 46, 3, 4-10.
- Altrichter, H. & Posch, P. (2009). Action research, professional development and systemic reform. In S. Noffke & B. Somekh (Eds.), *The Sage handbook of educational action research*, (pp. 213-225). Thousand Oaks: CA: Sage.
- Apple, M. (1993). *Official knowledge: Democratic education in a conservative age*. New York: Routledge.
- Archibald, Jo-ann. (1997). *Coyote learns to make a storybasket: Placing First Nations in education*. Unpublished doctoral dissertation, Simon Fraser University.
- Archibald, J. Q'um Q'um Xiim (2008). *Indigenous storywork: Educating the heart, mind, body, and spirit*. Vancouver, BC: UBC Press.
- Assembly of Alaska Native Educators. (1998). *Alaska standards for culturally responsive schools*. Fairbanks, AK: Alaska Native Knowledge Network, University of Alaska, Fairbanks.
- Au, K. H. (1979). Using the experience text relationship method with minority children. *The Reading Teacher*, 32, 677-679.
- Au, K. H. (1980). Participant structures in a reading lesson with Hawaiian children:

- Analysis of a culturally appropriate instructional event. *Anthropology and Educational Quarterly*, 11, 91-115.
- Averill, R., Anderson, D., Easton, H., Te Maro, P., Smith, D., Hynds, A. (2009). Culturally responsive teaching of mathematics: Three models from linked studies. *Journal for Research in Mathematics Education*, 40(2), 157-186.
- Barnhardt, R. & Kawagley, A. O. (2005). Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology and Education Quarterly*, 36(1), 8-23.
- Bartolomé, I. (1994). Beyond the methods fetish: Toward a humanizing pedagogy. *Harvard Educational Review*, 64(2), 173-195.
- Battiste, M. (2000). *Reclaiming Indigenous voice and vision*. Vancouver: UBC Press.
- Battiste, M. (2002). *Indigenous knowledge and pedagogy in First Nations education: A literature review with recommendations*. Ottawa, ON: Indian and Northern Affairs Canada.
- Battiste, M. (2008). The struggle and renaissance of Indigenous knowledge in Eurocentric education. In M. Villegas, S. R. Neugebauer, & K. R. Venegas (Eds.) *Indigenous knowledge and education: Sites of struggle, strength, and survivance* (pp. 85-91). Harvard Educational Review.
- Ben-Peretz, M. (1990). *The teacher-curriculum encounter: Freeing teachers from the tyranny of texts*. Albany: SUNY.
- Bielawski, E. (1990). *Cross-cultural epistemology: Cultural readaptation through the pursuit of knowledge*. Edmonton, AB: Department of Anthropology, University of Alberta.
- Bishop, A.J. (1988). *Mathematics enculturation: A cultural perspective on mathematics education*. Dordrecht: Kluwer Academic.
- Bragg, L. & Nicol, C., (2008). Designing open-ended problems to challenge preservice teachers' views on mathematics and pedagogy. In Figueras, O. Sepúlveda, A. (Eds.). Proceedings of the Joint Meeting of the 32nd Conference of the International Group for the Psychology of Mathematics Education and the XX North American Chapter Vol 2, pp. 256-270. Morelia, Michoacán, México: PME
- Burns R., Keyes, M. & Kusimo, P. (2005). *Closing achievement gaps by creating culturally responsive schools*. Charleston, WV: Edvantia.
- Cajete, G. (1994). *Look to the mountain: An ecology of Indigenous education*. Durango: Kivaki Press.
- Cajete, G. (1999). *Ignite the Sparkle: An Indigenous Science Education Curriculum Model*. Kivaki Press.
- Cajete, G. (2004). A pueblo story for transformation. In E. O'Sullivan & M. Taylor (Eds). *Learning toward an ecological consciousness: Selected transformative practices* (pp. 104-113). New York: Palgrave MacMillan.
- Canadian Council on Learning (2007). The cultural divide in science education for Aboriginal learners.
- Castango, A. E. & Brayboy, B. M. J. (2008). Culturally responsive schooling for Indigenous youth: A review of the literature. *Review of Educational Research*, 78(4), 941-993.
- Castellano, M. B. (2000). Updating Aboriginal traditions of knowledge. In G. Dei, B.

- Hall & D. Rosenberg (Eds). *Indigenous knowledges in global contexts: Multiple readings of our world* (pp. 21-36). Toronto: University of Toronto Press.
- Cazden, C.B. and Leggett, E.L. (1976) *Culturally Responsive Education: A Response to LAU Remedies II*. Report. United States of America
- Chisholm, A., Laquer, B., Hale, D., Sheorey, R. & McConville, Jr., A. (1991). *Making education relevant for contemporary Indian youth: A handbook for cultural curriculum developers focusing on American Indian Tribes and Canadian First Nations*. Norman, OK: The American Indian Institute, The University of Oklahoma.
- Churchill, W. (2004). *Kill the Indian, save the man: The genocidal impact of American Indian residential schools*. San Francisco, CA: City Lights Books.
- Civil, M., & Bernier, E. (2006). Exploring images of parental participation in mathematics education: Challenges and possibilities. *Mathematical Thinking and Learning* 8(3), 309-330.
- Connelly, M. & Clandinin, J. (1988). *Teachers as curriculum planners: Narratives of experience*. New York: Teachers College Press.
- Cooper, T., Baturo, A., Warren, E., & Grant, E. (2006). 'Aim high-beat yourself': Effective mathematics teaching in a remote indigenous community. In Novotná, J., Moraová, H., Krátká, M. & Stehliková, N. (Eds.). *Proceedings of the 2006 International Group for the Psychology of Mathematics Education, Vol. 2*, (pp. 369-376). Prague, Czech Republic. Charles University.
- Crespo, S. (2003). Learning to pose mathematics problems: Exploring changes in preservice teachers' practices. *Educational Studies in Mathematics*, 52, 243-270.
- D'Ambrosio, U. (1999). Literacy, matheracy, and technoracy: A trivium for today. *Mathematical Thinking and Learning*, 1(2), 131-153.
- Davis, B. (2001). Why teach mathematics to all students? *For the Learning of Mathematics*, 21(1), 17-24.
- Demmert, W. G. & Towner J. (2003). *A review of the research literature on the influences of culturally based education on the academic performance of Native American students*. Portland, OR: Northwest Regional Educational Laboratory.
- Dion, S. (2009). Braiding histories: Learning from Aboriginal peoples' experiences and perspectives. Vancouver: UBC Press.
- Dunkin, M. J. (1996). *Types of errors in synthesizing research in education*. Review of Educational Research, 66(2), 87-97.
- Erickson, F. & Mohatt, G. (1982). Cultural organization of participant structures in two classrooms of Indian students. In G. Spindler, (Ed.). *Doing the ethnography of schooling: Educational anthropology in action* (pp. 132-174). New York: Hold, Rhinehardt & Winston.
- Escobedo, T. H. (1978). Culturally responsive early childhood education: Programs for non-English speaking children. (Research Report, ERIC Document Number ED161277).
- Ezeife, A. N. (2002). Mathematics and culture nexus: The interactions of culture and mathematics in an Aboriginal classroom. *International Education Journal*, 3(3), 176-187.

- Friere, P. (1970). *Pedagogy of the oppressed*. New York: Continuum International.
- Gates, P., & Vistro-Yo, C. (2003). Is mathematics for all: In A. Bishop, M. Clements, C. Keitel, J. Kilpatrick & F. Leung (Eds.), *Second International Handbook of Mathematics Education* (pp. 31-73). Dordrecht: Kluwer.
- Gay, G. (2000). *Culturally responsive teaching: Theory, research, and practice*. New York: Teachers College Press.
- Gay, G. (2002a). Culturally responsive teaching in special education for ethnically diverse students: Setting the stage. *Qualitative Studies in Education*, 15(6), 613-629.
- Gay, G. (2002b). Preparing for culturally responsive teaching. *Journal of teacher education*, 53, 106-118.
- Gerdes, P. (1988). On culture, geometrical thinking and mathematics education. *Educational Studies in Mathematics*, 19(2), 137-162.
- Gómez, A., Fernández, M., Gómez, E., & Mas, J. (2009). The impact of action research in the Spanish school in the post-Franco era. In S. Noffke & B. Somekh (Eds.), *The Sage handbook of educational action research*, (pp. 481-494). Thousand Oaks: CA: Sage.
- Government of Canada. (1996). *Report of the Royal Commission on Aboriginal Peoples*. Ottawa, Ontario: Canada Communication Group. Retrieved [March 8th of 2009] from <http://www.ainc-inac.gc.ca/ap/rrc-eng.asp>.
- Greer, B., Mukhopadhyay, S., Powell, A., Nelson-Barber, S. (2009). *Culturally responsive mathematics education*. New York: Routledge.
- 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, 709-737.
- Gutstein, E. (2006). *Reading and writing the world with mathematics. Toward a pedagogy of social justice*. New York: Routledge.
- Habermas, J. (1981). *Theory of communicative action*. (T. McCarthy, Trans.). Frankfurt: Suhrkamp.
- Henningsen, M. & Stein, M. (1987). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. *Journal for Research in Mathematics Education*, 28, 524-549.
- Heron, J. & Reason, P. (2006). The practice of co-operative inquiry: Research 'with' rather than 'on' people. In P. Reason, & H. Bradbury (Eds.) *Handbook of action research* (pp. 144-154). Thousand Oaks, CA: Sage.
- Howson, A. G., Keitel, C., & Kilpatrick, J. (1981). *Curriculum development in mathematics*. New York: Cambridge University Press.
- Kirkness, V. J. (1998). Our peoples' education: Cut the shackles; cut the crap; cut the mustard. *Canadian Journal of Native Education*, 22(1), 10-15.
- Kirkness, V. J. & Barnhardt, R. (1991). First nations and higher education. *Journal of American Indian Education*, 30(1), 1-15.
- Kitchenham, A. (2008). The evolution of John Mezirow's Transformative Learning Theory. *Journal of Transformative Education*, 6(2), 104-123.
- Klingner, J. K., Artiles, A. J., Kozleski, E., Harry, B., Zion, S., Tate, W., Durán, G. Z., &

- Riley, D. (2005). Addressing the disproportionate representation of culturally and linguistically diverse students in special education through culturally responsive educational systems. *Education Policy Analysis Archives*, 13(38). Retrieved [March 8th of 2009] from <http://epaa.asu.edu/epaa/v13n38/>.
- Knijnik, G. (1997). An ethnomathematical approach in mathematics education: A matter of political power. In A. Powell & M. Frankenstein (Eds.), *Ethnomathematics: Challenging eurocentrism in mathematics education* (pp. 403-410). Albany: SUNY.
- Knijnik, G. (1993). An ethnomathematical approach in mathematical education: A matter of political power. *For the Learning of Mathematics*, 13(2), 23-25.
- Kuhn, T. (1980). *The structure of scientific revolutions* (2nd ed.). Chicago, IL: University of Chicago Press.
- Kuokkanen, R. (2007). *Reshaping the university: Responsibility, Indigenous epistemes, and the logic of the gift*. Vancouver: UBC Press.
- Ladson-Billings, G. (1995a). But that's just good teaching: The case for culturally relevant pedagogy. *Theory into Practice*, 34(3), 159-165.
- Ladson-Billings, G. (1995b). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*. Vol. 32, No. 3 pp.465-491
- Lipka, J., Sharp, N., Adams, B., & Sharp, F. (2006). *Connecting out of school learning to school mathematics: Qualitative and quantitative data from Alaska*. Paper presented at the American Educational Research Association Annual Meeting 2007, San Francisco.
- Lipka, J. Sharp, N., Adams, B., Sharp, F. (2007). Creating a third space for authentic biculturalism: Examples from math in a cultural context. *Journal of American Indian Education*, 46(3), 94-115.
- Luitel, B.C., Taylor, P.C. (2007). The shanai, the pseudosphere and other imaginings: Envisioning culturally contextualized mathematics education. *Cultural Studies of Science Education*, 2, 621-655.
- Marker, M. (2006). After the Makah whale hunt: Indigenous Knowledge and the limits of multicultural discourse. *Urban Education*, 41(5), 1-24.
- Marshall, A., Williams, L. and Stewart, S. (2008). Indigenous education. Principles and practice. In R. Wesley Heber (Ed.), *Indigenous education Asia/Pacific* (pp. 167-177). Saskatchewan: Indigenous Studies Research Centre, First Nations University of Canada.
- Merriam, L., Brown, R. Cloud, H., Dale, E., Duke, E., Edwards, H. et al. (1928). *The problem of Indian administration: Report of a survey made at the request of the Honorable Hubert Wrok, Secretary of the Interior, and submitted to him, February 21st, 1928*. Baltimore, MD: The Brookings Institute.
- Mezirow, J. (1978). *Education for perspective transformation: Women's re-entry programs in community colleges*. New York: Teacher's College, Columbia University.
- Mezirow, J. (1997). Transformative learning: Theory to practice. *New Directions in Adult and Continuing Education*, 74, 5-12.
- Mezirow, J. (2000). *Learning as transformation: Critical perspectives on a theory in progress*. San Francisco: Jossey-Bass.

- National Indian Brotherhood. (1972). *Indian control of Indian education*. Ottawa, Ontario: Author.
- Nelson-Barber, S. & Estrin, E. T. (1995). *Culturally responsive mathematics and science education for Native students*. San Francisco, CA: Far West Laboratory for Educational Research and Development.
- Nicol, C. (1999). Learning to teach mathematics: Questioning, listening, and responding. *Educational Studies in Mathematics*, 37, 45-66.
- O'Sullivan, E. (1999). *Transformative learning: Educational vision for the 21st century*. Toronto, Ontario, Canada: University of Toronto Press.
- O'Sullivan, E., & Taylor, M.M. (Eds.) (2004). *Learning toward an ecological consciousness: selected transformative practices*. New York: Palgrave Macmillan.
- Ogbu, J. (1987). Variability in minority school performance: A problem in search of an explanation. *Anthropology and Education Quarterly*, 18, 312-334.
- Orr, D. W. (2004). *Earth in mind: On education, environment, and the human prospect* (10th anniversary Edition). London: Island Press.
- Pewewardy, C. D. (1998). Culturally responsive teaching for American Indian learners. Paper presented at the *Kansas Institute on Effective Teaching Practices for Indian Education*, Lawrence, KS (November 19).
- Pewewardy, C.D. & Hammer, P.C. (2003). *Culturally responsive teaching for American Indian students* [ERIC Digest]. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.
- Philips, S. (1983). *The invisible culture: Communication in classroom and community on the Warm Springs Reservation*. New York: Longman. (ERIC Document Reproduction Service No. ED 226 878).
- Phuntsong, N. (1999). The magic of culturally responsive pedagogy: In search of the genie's lamp in multicultural education. *Teacher Education Quarterly*, 26(3), 98-111.
- Reason, P. & Bradbury, H. (2006). *Handbook of action research*. Thousand Oaks, CA: Sage.
- Reyes, M. de la Luz. (1992). Challenging venerable assumptions: Literacy instruction for linguistically different students. *Harvard Educational Review*, 62, 427-446.
- Sarris, G. (1993). *Keeping Slug Woman alive: A holistic approach to American Indian texts*. Berkeley, CA: University of California Press.
- Schon, D. (1983). *The reflective practitioner*. New York: Basic Books.
- Silko, L. (1981). *Storyteller*. New York: Seaver Books.
- Sioui, G. (1992). *For an Amerindian autohistory: An essay on the foundations of a social ethic*. Montreal and Kingston: McGill-Queen's University Press.
- Smith, G.H. (1997). *Kaupapa Maori: Theory and praxis*. Ph.D. Thesis, Education Department; The University of Auckland. Auckland, NZ: The International Research Institute for Maori and Indigenous Education.
- Smith, G.H. (2003). Indigenous Struggle for the Transformation of Education and

- Schooling. *Keynote Address to the Alaskan Federation of Natives Convention*, October, Anchorage, AK. http://www.kaupapamaori.com/assets/indigenous_struggle.pdf (retrieved March 18, 2009)
- Smith, L. T. (1999). *Decolonizing methodologies: Research and indigenous peoples*. New York: St. Martin's Press.
- Statistics Canada (2001). 2001 Census of Canada. Retrieved [March 20th of 2009] from <http://www12.statcan.ca/english/census01/home/Index.cfm>.
- Stenmark, J. (1991). *Mathematics assessment: Myths, models and good questions*. Reston, VA: National Council of Teachers of Mathematics.
- Sterling, S. (2001). *Sustainable education: Re-visioning learning and change*. Devon, UK: Green Books.
- Sullivan, P. & Lilburn, P. (2002). *Good questions for math teaching: Why ask them and what to ask*. Sausalito, CA: Math Solutions Publications.
- Transformative Learning Centre. (2004). *The Transformative Learning Centre*. Retrieved July 27, 2004, from Transformative Learning Centre Web site: <http://tlc.oise.utoronto.ca/index.htm>
- Urien, C. (1999). Changing academic discourse about native education: Using two pairs of eyes. *Canadian Journal of Native Education*, 23(1), 6-15.
- Villegas, A.M. (1988). School failure and cultural mismatch: Another view. *The Urban Review*, 20, 253-265.
- Villegas, A.M. & Lucas, T. (2002a). *Educating culturally responsive teachers: A coherent approach*. New York: State University of New York Press.
- Villegas, A.M. & Lucas, T. (2002b). Preparing culturally responsive teachers: Rethinking the curriculum. *Journal of Teacher Education*, 53(1), 20-32.
- Wideen, M., Mayer-Smith, J. Moon, B. (1998). A critical analysis of the research on learning to teach: Making the case for an ecological perspective on inquiry. *Review of Educational Research*, 68(2), 130-187.
- Yazzie-Mintz, T. (2007). From a place deep inside: Culturally appropriate curriculum as the embodiment of Navajo-ness in classroom pedagogy. *Journal of American Indian Education*, 46(3), 72-93.

TEAM-Learning Circle - Project Background Information

Name _____

School _____

Date _____

Section 1: Background Information

1.1 What grade(s) do you currently teach? (Please circle all that apply)
K 1 2 3 4 5 6 7 8 9 10

1.2 How many years have you taught at the this level? _____

1.3 How many years of teaching experience do you have in total? _____

1.4 Please circle your age range: 20-30 31-40 41-50 50+

1.5 How did you train for your current qualifications?

1.6a What kinds of professional development in mathematics education have you participated in? Please describe.

1.6b Please share what you think about this professional development in terms of its impact on your teaching.

1.8 How would you rate your *personal background knowledge* of mathematics?
(poor) 1 2 3 4 5 (excellent)

comments:

1.9 How confident do you feel in your teaching of mathematics?
(not at all) 1 2 3 4 5 (highly confident)

comments:

1.10 How confident do you feel in your ability to help students who struggle with mathematics?
(not at all) 1 2 3 4 5 (highly confident)

comments:

1.11 How do you use what your students know to help in your math lesson planning?

Section 2. Teaching Mathematics

2.1 Which area(s) of mathematics do you enjoy teaching the most?

2.2 Which area(s) of mathematics do you NOT like teaching?

2.3 A typical mathematics lesson in my classroom looks like...(please describe)

2.4 What aspects of your mathematics teaching would you like to improve?

2.5 How much time do you typically spend on mathematics in your class each week?

Section 3. Learning Mathematics

3.1 What is it about mathematics that your students enjoy?

3.2 What is it about mathematics that your students don't enjoy?

3.3 What do you think best helps students learn mathematics?

Section 4. Aboriginal Knowledge, Culture and Community

4.1a How would you rate your personal knowledge of local Aboriginal culture?
(minimal) 1 2 3 4 5 (thorough)

comments:

4.1b How would you rate your personal knowledge of the local community?
(minimal) 1 2 3 4 5 (thorough)

comments:

4.2 In what ways (if any) does your personal knowledge of Aboriginal culture and/or the local community play a role in your teaching? Please explain.

4.3 In what ways (if any) does your knowledge of Aboriginal culture and/or the local community play a role in your teaching of mathematics? Please explain.

Section 5. The Emotional Experience of Mathematics

- 5.1 What word (or words) best describe(s) your feelings about mathematics?

- 5.2 What word (or words) best describe(s) your feelings about your own learning of mathematics?

- 5.3 What word (or words) best describe(s) your feelings about teaching mathematics?

- 5.4 What word (or words) best describe(s) how you think your students feel about learning math?

- 5.5 What one word best describes the atmosphere of your classroom when students are learning math?

Section 6. The Research Project

- 6.1 How enthusiastic do you feel about being involved with this project?
(not much) 1 2 3 4 5 (highly enthused)
comments:

- 6.2 What concerns do you have about being involved with this project?

6.3 What would you like to get out of the project?

6.4 What questions do you have about the project?

Thank you for taking the time to share your beginning thoughts about the project. We look forward to working with you and the group. Please don't hesitate to follow-up with other ideas or comments that you might have.

Participant/Co-researcher Feedback Questionnaire—

Please respond with details and examples so that we have a good sense of your experience in the project - thank you.

Name _____

School _____

Date _____

Section 1:

1.3 Please describe your position in the district?

1.4 How many years have you been in this position or have been teaching?

1.5 A colleague in the district is aware of your participation in TEAM-Learning and asks you what the project is about, how would you respond?

1.6 How would you describe your involvement in the project

1.7 List three things that have stood out for you related to the TEAM-Learning project to date. Please describe how/why these stood out for you.

-

-

-

1.8 Consider your experience in the project to date and complete this sentence:
I used to think but now I think

1.9 Considering the project what would you like

- More of....

- Less of.....

1.10 What are three significant goals that you have for your mathematics teaching next year?

1.11 How has involvement in the project influenced (or not) your thinking about
(please describe)

a) Mathematics (eg math curriculum, problem solving, what it means to do math...)

b) Students (eg emotional connections, mathematical thinking, interest in math...)

c) Culture/community (eg. Local community, IPL culture, traditional and contemporary cultural activities, connections to math and students...)

d) Teaching and learning math (eg diversity, culturally responsive, achievement, success, interest ...)

1.7 What do you feel you need more of in order to teach math in the way you envision in your school?

1.8 What areas/issues/topics would you like to explore further during our project meetings?

Please feel free to provide other comments, questions and feedback....

Interview Questions

TEAM -Learning [Transforming Education for Aboriginal Mathematics- Learning]

Interviewer: please arrange a time for the interview that is convenient for you and the interviewee. You need about 1 hour for the interview plus 30 minutes for set-up time for you. Please send the interview questions to the teacher about within a week before the interview. You could introduce yourself as a teacher but new to the project - this will be a good guise for asking questions that might be obvious to the interviewee or to me.

Please let the teacher know that they will have the chance to review the transcript of the interview. No quotes will be used that identify them unless they give permission. False names of district and school can be used. Ask if it is okay for you to record the conversation.

You could print one set of these questions for each interview and write your notes below each question

Name:

Date:

Interviewed by:

Background information:

- 1.12 Please describe your teaching background. (eg ... How many years teaching, which grades, specialty areas, grade currently teaching (how many years teaching at this level), schools taught in, how many years teaching at this current school etc...
- 1.13 How would you describe your school? (eg how many students, how many teachers, background of general student population, how many students in your class this year, general background of students in your class, etc...
- 1.14 Please describe a typical math class or series of math classes - what would you be doing, what would students be doing... (what would teacher be doing... class work, text book use ... etc)
- 1.15 How do you prepare for a typical math lesson? What resources, how do you choose problems, ...

Conceptualization

2.1 Think back to the beginning of the school year this year - what are your goals for the year with your class? And what made these goals important for you?

2.2 If someone, say one of your colleagues, asks you why you are involved in the project.... how would you respond?

Experience

3 List **three** things that have stood out for you related to the project to date. Please describe how/why these stood out for you. [ask for examples - get details; if the following not mentioned ask about their thoughts on ...the math conference, community members attending meetings)

3.2 Consider your experience in the project to date and complete this sentence: "I used to think but now I think"

3.3 I understand that you've tried some lessons/activities in your class related to the project. What have you tried? What did you learn from this? [If the teacher wasn't able to try some activities please ask him/her to explain what made it difficult or what may have prevented trying the activities.

Conceptualization 2

- 4.1 Okay, not an easy question ... What does culturally response education mean to you? What does it look like in a mathematics classroom?

- 4.2 What is needed for teachers to teach culturally responsive math? What is needed for you to teach the way you envision?

Project Group Meetings

- 5.1 How often does the group meet?. What role do the meetings play for you? How useful are the meetings? [ask for details and examples]

- 5.2 Would you say the group meetings are needed for the project? If so how/why? [probe - could you say more; what do you mean...I'm interested in learning more about whether or not the guest speakers, museum project, readings, activities were most/least useful in supporting the teacher's learning].

- 5.3 What have you learned from the project? [could probe with questions around math, understanding students, understanding community/culture, and teaching learning math; What counts as a good math problem).

- 5.4 Is there something you'd like to try in your classroom related to culturally responsive math education that you haven' t tried yet but would like to?

Support

- 6.1 What kind of support do you feel you get from your school to be involved in the project? (Probe: how supportive is the administration? in what ways). What about from the school district? And from the community (eg parents, students)?

- 6.2 What support do you think you/the group needs to make a difference?

- 6.3 What do you think is needed in order to sustain the project after this year? Or do you think it is possible?

Wrap – up

- 7.1 Can you think of anything else you'd like to share?

- 7.2 Is there anything you'd like to ask me?

Please thank the teacher and let them know that they could e-mail you if they think about anything else to add.

Please ask if it is okay for you contact her/him with some follow-up questions or clarification if needed.

Follow-up with a thank you e-mail

Guiding interview/discussion questions for discussions with participating teachers

Conceptualizing CRE

- CRE can mean many different things to different people and a person's experience with and conceptualizing of it can change. At this point in time what does culturally responsive education mean to you?
 - home, school links?
- What are some key aspects of CRE that are important to you? What makes these important?
 - What role does improving self-esteem have in CRE?
 - What role does improving academic competence have?
 - role of community? of school? structures?
- Some people use the term culturally relevant or culturally responsive. I've preferred using responsive. So it made me think....What is CRE responding to – what is it responsive to – from your perspective?
- Considering the results of the FSAs and provincial exams for IPL... and that the province reports results for Aboriginal and non-Aboriginal students – and that these are general results focusing on a group rather than individuals - from your experience what do you think accounts for the difference in achievement between Aboriginal and non Aboriginal students?
- Some people would say that CRE has a collective not only an individual component to it where students develop some competency to challenge the way things are – to engage the world and others critically. How does this fit with your thinking about CRE?

Actualizing CRE

- What does CRE look like in your classroom? Example
 - In planning a math lesson for CRE what do you consider? *At the beginning of the project few people said they had thought about culture and math*
 - How is teaching for CRE in mathematics different from teaching for CRE in other subject areas?
 - How is teaching for CRE different from just plain teaching?
- What makes teaching for CRE challenging? How do you address these challenges? Can all these be addressed? Why or why not?
- Some might feel an expectation or obligation to teach for CRE? What do you think; do you feel there is this expectation? Is it a personal self-imposed expectation and/or an institutional expectation?
- Some say there are tensions between teaching for CRE, meeting academic standards and addressing accountability such as achievement. What is your experience – is there this kind of tension for you? How do you negotiate these?
- How does a teacher learn to teach for CRE?
 - Who are your mentors? Where do you go?
 - What has been helpful for you in learning to teach for CRE?
 - If you had to think of 3 factors that have supported your learning to teach for CRE what would they be?
- What have you learned from your students in teaching for CRE?
- What is your own assessment of your teaching for CRE? Are you satisfied with what you've accomplished to date? What will you change? What will you keep?

Identifying

- ancestry – does it matter? Some people say that the ancestry of the teacher matters in teaching for CRE. What do you think – does it matter for you?
 - Some say ancestry matters for students. What do you think?
- Has teaching for CRE helped you “call into question” certain truths about students or about teaching math or about culture? Has the project changed your views of how you see yourself as a teacher? If so, how?
- What role does the community or parents/guardians play in your teaching for CRE? What are some of the challenges related to this?
 - What meaning do cultural activities have for you? Inclusive?
- How does the school reflect the values that are important to you as a teacher?
- How does the school reflect values that are important to all students (and Aboriginal students)?
 - do schools/district’s goals for teaching math fit your own?
- CRE generally and CRE math education. What’s the diff?

Curriculum and Teaching Materials developed by participating teachers and available to all IPL teachers and community members now and to all other teachers in the future:

- Seeing Math in IPL: Land, Sea and Sky (math photobook)
- Seeing Math in IPL Resource book to accompany the photobook
- Partitioning Buoys Lesson K-3
- Probability Buoys Lesson Grade 4-10
- Legends Raven Brings the Light: Lesson K-3
- Legends Raven Brings the Light: Grade 4 – 12
- Math and Tluu Waadluxaan, The Everything Canoe (math photobook)
- Crab Traps Waiting Lesson Grade 5-10
- Logging in IPL Lesson Grade 5-10
- Clam Shell Measuring Lesson K-5
- Math, Beauty and Mystery of Bentwood Boxes Lesson Grade 5-10
- The Math and Magic of Button Blankets (math photobook)
- Patterns at the Beach (math photobook)
- Math Problem Solving (photobook) and Smartboard activities
- Weaving and mathematics (photobook)
- Feet at the River: Lesson Grade 2 – 7