

FINDING POETIC JUSTICE: HOW TEACHER INQUIRY IMPACTS
ELEMENTARY MATH INSTRUCTION

by
Kathleen McCarroll Moore
B.A. (State University of New York at Albany) 1978
M.A. (Saint Mary's College of California) 2007

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Abstract

African American students, commonly designated a sub-group in assessment data reports, consistently score well below their peers in mathematics. A consequence of this phenomenon is that math teachers often feel obligated to provide remedial methods of instruction focused on recall and repetitive practice, believing that these strategies will result in an increase in mathematical proficiency and lead to a narrowing of the achievement gap. This practice is socially unjust, excluding low-achieving math students from experiencing intellectually challenging or engaging math content, and limiting their academic opportunities. This study was designed to explore teacher attitudes and practices through an inquiry case study at a Title 1 elementary school in a high-performing suburban school district. Five elementary teachers self-assessed at the beginning and at the close of the study; they participated in a series of collaborative sessions to examine culturally relevant pedagogy, and to plan, deliver, and revise lessons using instructional methods deemed considerate of the cultural strengths that individual students bring to the classroom.

Taking the stance of poetry as a form of culturally relevant pedagogy allowed the researcher to infuse poetry texts and research articles linking math and poetry into every phase of the inquiry case study. Participants reported an increase in student engagement during math instruction which mirrored the participants' reported change in attitudes and

instructional practices as determined through interviews, audio taped study sessions, and pre and post self-assessments. Analyzed and coded data culled from these sources revealed three major issues: students who struggle early continue to lag behind their peers, compartmentalization of math instruction leads to an inability to recognize its relevance, and lack of enthusiasm for math results in a lack of mathematical understanding.

The research findings highlight the importance of establishing a community of practice built on trust in order to bring about change. Study participants reported that the strategies designed and implemented provided connections between language and math that made the learning experience more relevant and accessible. The study did not examine whether the increase in engagement resulted in increased mathematical comprehension although it did suggest a link between the two; further study is warranted.

California State University, East Bay
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This dissertation was presented
by

Kathleen McCarroll Moore

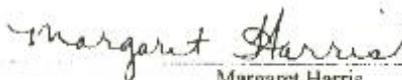
It was defended on
April 6, 2012
and approved by:



Jeanette Bicaïs, Chair
Teacher Education Dept.
California State University East Bay



Matis Pouncil
Department of Educational Leadership
California State University



Margaret Harris
Department of Educational Leadership
California State University

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*I guess we can't help it, The moment just found us
The timing was perfect, the energy boundless
We both read each other, words aren't necessary
Like dancers in rhyme, we're involuntary
We think as one person without concentrating
I'm high on your laughter, it's intoxicating*

Thank you for providing humor, energy, and love; thank you for accompanying me on this journey.

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CHAPTER 1

INTRODUCTION TO THE STUDY

The human aesthetic is strongly rooted in pattern and repetition; we seek symmetry in form in most arts, as well as in science. The mathematician seeks an 'elegant' proof above one which demonstrates the same result through contradiction or examination of numerous cases. He prefers one with a 'symmetry'; many proofs require the logic to follow in both directions at once. He seeks the simple, the fundamental from which to build his great mathematical structures. The artist or poet seeks a similar symmetry in many ways; the metre of poetry is a subtle counting, and the words chosen are a concise reflection of the experience of the poet. He seeks to give his poem a contained, elegant form, with verses and stanzas showing the inner symmetry of thought.

The mathematics we choose to hate in school is not the mathematics which, being a part of our soul, we will always love. As Gottfried Leibniz said, "Music is the pleasure the human soul experiences from counting without being aware that it is counting." It is true of all arts, for symmetry and pattern are the manifestations of mathematics.

Dr. Katherine Stange (2011)

Background

I am not a mathematician.

I am a writer, a poet, a lover of words. I have spent my career teaching English and coaching English teachers; I believe in the power of language to construct and shape and define our lives. As a researcher and practitioner, I have framed my social justice work through the lens of literacy, believing that giving students the tools to articulate their lives is a moral imperative. How then, did I decide to focus my energies on the attitudes and practices of elementary math teachers?

The answer is simple; it starts with a story. Or rather, it begins with counter-story.

Solórzano and Yosso (2002) define the counter-story as a method of telling the stories of those people, often on the margins of society, whose experiences are not told.

Many teacher education programs continue to contribute to a system of intellectual and cultural deprivation by promoting the majoritarian stories that have served as the foundation of the American educational system. Although educational researchers such as Ladson-Billings (1995a, 1997) and Gay (2002) have written extensively about the need for incorporating culture, experience, and perspectives of ethnically diverse students into teacher preparation programs, this has often not been the case. This study is an attempt to shed light on the stories of under-achieving elementary math students by facilitating a process of teacher inquiry focused on mathematics instruction and culturally relevant pedagogy. I will be presenting research that examined the attitudes and instructional practices of a group of teachers; several of their under-achieving students referred to in the study are African American.

As Cummins (2001) points out in *Empowering Minority Students: A Framework for Intervention*, “pedagogical approaches that empower students encourage them to assume greater control over setting their own learning goals and to collaborate actively with one another in achieving these goals” (p. 667). He goes on to indict the predominant educational practices that disallow student empowerment – that ensure that marginalized students consistently receive instruction that “convinces them that what they have to say is irrelevant or wrong” (Cummins, 2001, p. 663). This was the case in student after student that I worked with in a continuation high school setting in a high-performing suburban school district in northern California, and this experience convinced me of the need to promote a social justice agenda in my mentoring work with teachers.

I have been involved in teacher education and its connection to social justice for much of my career. Many education researchers agree with Schmoker's (2011) contention that "the actual curriculum an average child learns in the same course and in the same school varies tremendously from teacher to teacher. What you learn depends on what teacher you have" (p. 13). When teachers lack cultural competency or do not know how to connect with their students, learning suffers. According to Ladson-Billings (1995a), culturally relevant teachers are able to "utilize students' culture as a vehicle for learning" (p. 161).

Teachers who do not make this connection to their students do them a grave disservice. On the other hand, as Cummins (2001) points out, when teachers redefine their roles and become advocates for all their students, real transformation can take place. Advocating for students includes focusing on student empowerment, linking reciprocal interaction to an increase in confidence, motivation, and academic success. Societal transformation can be accomplished when minority students are empowered by their schooling instead of disabled by it.

As a literacy leader working in dozens of settings, I find it interesting to note that instructional practices and prescribed school curricula routinely offer rote exercises in the name of intervention or support which do little to promote academic literacy, critical thinking, and the development of a strong intellectual identity. Schools have a responsibility to prepare all their students as citizens for the future; however, the educational pipeline continues to flush students out of the system, denying them social capital and opportunities to fully participate in society. The system in place reproduces

ethnic, cultural, and socio-economic biases in an effort to maintain the status quo. Whether or not it is intentional, it is effective in denying academic advancement and higher education opportunities to large numbers of students. Teachers play an important role in this instructional inequity, but I believe with the proper support and professional development opportunities, they can begin to right this wrong.

It is because of this need for teacher mentoring and support that I undertook this study. Despite the entrenched culture of bias and oppression that challenges our students, we can and we must make a concerted effort to disrupt the status quo and make a difference – a real difference – for all students.

Significance of the Study

For the past several years I have worked with students at a continuation high school in a high-performing suburban school district, introducing them to reading, writing, and performing poetry, especially poetry with a social justice agenda. These students, most of whom have exhibited a tenuous relationship with schooling, showed a marked increase in engagement and classroom participation through our work together (Moore, 2007, 2010). My observations of these students, coupled with the inevitable questions that arose concerning the typical continuation high school student profile, nagged at me. As is the case in many such schools, I saw a disproportionate number of African American and Latino youth represented at the continuation high school; this phenomenon was particularly noteworthy given the demographics of the predominantly White community from which they were drawn. I was interested in exploring the conditions that led so many of these students along the path to an alternative high school

setting; was there a particular set of circumstances that could be identified early in the students' education? Could race alone be the determining factor?

As my interest in this obvious injustice began to grow and shift, I began researching those students who fall into the at-risk category in elementary school. A dialogue I had with a colleague underscored the striking inequities in mathematics achievement evidenced in district elementary schools. This was particularly evident in a Title 1 school where, due to changing demographic growth patterns, including an increase of immigrant families and an introduction of Section 8 housing, the population exhibited considerably more diversity than did the other schools in this high-performing suburban community. (This school will be referred to as Nature Refuge Elementary or NRE throughout the rest of this paper). In the book, *Black American Students in an Affluent Suburb: A Study of Academic Disengagement* (2003), Ogbu discusses the issue of academic insecurity prevalent in African American males and he quotes a school counselor who claims that the problem of the non-learner self-image begins as early as first grade. This is borne out, I believe, in the students I have observed in elementary classrooms. These students who are not yet continuation high school students, but whose profiles suggest they one day could be, motivated me to adjust my research lens.

*We shape our self
to fit this world*

*and by the world
are shaped again.*

(David Whyte, from the poem *Working Together*, 1996)

Looking more closely at these elementary remedial math students illuminated the similarities I recognized between them and my continuation high school students. A quick tally of fifth grade math students at Nature Refuge Elementary (NRE) in the spring of 2011 indicated the following: in the advanced math class, there were no African American students, one White student, and more than twenty Asian students. The lowest-tracked remedial math class included a disproportionate number of African American students. Knowing that math proficiency is considered a gatekeeper for higher education, I could not help but wonder at what point these remedial math students, predominantly African American males, might find themselves on a path leading to alternative education programs. Gregory, Nygreen, and Moran (2006) refer to this phenomenon as the normalization of failure, explaining that it becomes accepted in society that a predictable group of students will never achieve proficiency. This knowledge led me to wonder if a focus on poetry might be an effective way to build confidence and skills and help students connect to their learning and their lives in meaningful ways. I began to consider the idea that poetry could actually be designed to act as a sort of culturally relevant pedagogy; this, in turn, led me to theorize that poetry as an intervention strategy could have an impact on the educational trajectories of struggling math students. If traditional math instruction was not meeting the needs of the African American students I observed at NRE, I proposed that an inquiry process should be established to examine which methods of instruction would be effective. I decided to explore whether strengthening academic math skills, while building an educational identity through poetry immersion, could help to disrupt the cycle of failure that plagues many African American students.

The majority of remedial math classes being disproportionately comprised of African American students is not an issue that is unique to urban schools; this trend is also evident in high-performing suburban school settings. Current research indicates that this phenomenon is widespread, and National Assessment of Educational Process data reveals that math proficiency continues to divide disproportionately along racial lines (Berry, 2003). Math is considered a gatekeeper in higher education, and the achievement gap continues to plague many of our public schools, no matter the community. Therefore, it is important to explore teacher attitudes and instructional strategies that might lead to an interruption of this practice. Studying the impact of teacher inquiry focused on culturally relevant pedagogy and mathematics instruction may help to shed some light on the topic and contribute to the conversation on more equitable math instruction.

"You do not study mathematics because it helps you build a bridge. You study mathematics because it is the poetry of the universe. Its beauty transcends mere things."
(Jonathan David Farley, 2011, p. A)

This is where my poetry work with continuation high school students and my research interest in elementary mathematics instruction intersect. Because mathematics is such a gatekeeper in education (Bol & Berry, 2005, Stinson, 2004), it is critical to search for alternative methods of instruction that support all students and their learning. This is a social justice issue that I believe needs immediate attention if we are to stop the cycle of failure for students of color that has become the norm in our educational system.

There is a great deal of research on the power of poetry in literacy instruction (Stovall, 2006; Weinstein, 2009); much less research has explored the impact of poetry in the mathematics classroom. Research continues to reveal that while mathematics is

considered the gateway to higher education, statistically African American boys fall far below their classmates in math proficiency (Muhammad, 2003; Noguera, 2003; Snipes & Waters, 2005). An interesting connection between students' lower achievement and the way they are taught and tested seems to surface when we look closely. Snipes and Waters (2005) suggest that one cause of the poor math performance of African American students is that there is a disconnect between classroom instruction and their home environments; the curriculum does not reflect the life experiences of these students. Ladson-Billings (1995a) stresses that when teachers' pedagogical stance is one of cultural relevance, they are able to utilize students' culture as a vehicle for learning. It seems likely then that culturally relevant methods of instruction could support African American students' ability to access math content and demonstrate their mathematical understanding. As an educator, I am interested in exploring new, unconventional instructional methods that support academic achievement for all students.

Of vital importance in education today is the ever-widening academic achievement gap between White students and students of color, especially African American males. These students bear the brunt of the attention and the blame for an educational crisis that sees a disproportionate number of African American youth falling behind and failing in traditional school settings only to be reassigned to alternative programs, or to otherwise becoming an educational statistic. There is a current of institutionalized racism that underlies this phenomenon (Knaus, 2009; Ladson-Billings, 1999); an acceptance that not all students will be successful in the factory-model educational system that defines the American public school system. This reasoning

results in access and opportunity being at odds with the basic tenets upon which our nation was founded, with liberty and justice for all.

In a broader sense, this topic is related to socially-accepted notions of what school is for, how students should learn, and how teachers should teach. Over the past decade, more attention has been paid to student engagement and access to the curriculum (Jocson, 2006; Knaus, 2009; Stovall, 2006). Researchers have increasingly focused on practices that strengthen the engagement of marginalized students through the study of poetry, particularly social justice poetry (Jocson, 2006; Knaus, 2009; Stovall, 2006). This research advocates for student voice: designing educational experiences that help students develop a positive sense of themselves as learners, thinkers, and doers. I agree with the stance taken by Berry (2003), which finds that African American students have been underserved in mathematics instruction; teachers who understand the role that culture plays in learning can empower African American students to become strong and successful mathematicians.

Statement of the Problem: The Opportunity Gap

*Where then are the roots, where the solution
to life's equation?*

(a line from the poem *Zero-Sum Game* by Nigerian poet, Christopher Okigbo, 1932-1967)

Mintrop and Sunderman (2009) present evidence that No Child Left Behind (NCLB) Legislation, purportedly enacted to narrow the achievement gap, has done nothing of the sort. In fact, their research findings indicate that the NCLB approach to education has made it even more difficult for schools with diverse student populations to reach their targeted goals due to the attendant complexity that diversity brings. Most

disturbing is the practice of excluding low-achieving students from content that is intellectually challenging or engaging (Beers, 2009).

The African American students I have been working with at NRE, a Title 1 elementary school in a suburban school district, have shown little improvement in their math proficiency despite targeted math interventions that have been implemented. In the 2010-2011 school year, I conducted a pilot study with an inquiry group consisting of classroom teachers, a literacy coach and a principal; together we explored various alternative methods of intervention. One such intervention grew out of my work with poetry instruction for continuation high school students. Because the continuation students that I worked with showed a marked increase in engagement and writing proficiency through reading and writing poetry, I wondered if it might not be possible to increase student engagement in elementary math through an increased exposure to poetry instruction, thus building self-confidence, empowering student voice, and improving math achievement. Minton (2007) and Schmoker (2011) stress the critical connection between numbers and words, and the necessity of incorporating language literacy into mathematics instruction. Creating literate mathematical thinkers is central to the teaching of math, the primary purpose of which is to “make and dismantle... logical arguments that tie evidence to conclusions” (Schmoker, 2011, p. 203).

Dr. Russ Skiba, in a 2010 speech, emphasized the importance of using data to inform responses to classroom inequities and low achievement for students of color. His call to let the data speak was followed by a paradigm-shifting statement: “What the data speaks depends on the color of our ears.” In other words, the experience, the perspective,

and the cultural understanding of the analyst play a significant role in the interpretation and articulation of the data. Educators, policy-makers, and researchers must be mindful, when interpreting and analyzing numbers like achievement gap statistics, to look beyond the obvious. For example, we might question whether African American students' lower performance on standardized assessments is due to facility with numbers, inequitable or culturally biased assessments, or teachers with low expectations or a lack of cultural competency. Because I agree with Skiba's observations that classrooms must be environments that provide activities and outcomes to benefit all students, I believe incorporating culturally responsive methods of instruction into the curriculum is one way to achieve this goal. I am interested in adding to the conversation on this topic through my research.

Active participation and confidence-building are strategies that should serve as first steps in breaking down the barriers that challenge African American boys to succeed in the math classroom, and to counter the oppositional identities that researchers have reported as roadblocks to the achievement of these students (Noguera, 2003). It has been shown that lack of confidence in one's ability can actually impede academic performance, a phenomenon that is particularly prevalent among African American and Hispanic students (Muhammad, 2003, p. 114). The inquiry group that I worked with through a pilot study postulated that instructional strategies focused on engagement and positive support might allow students who struggle with mathematical concepts to improve their comprehension and computational skills. In beginning the subsequent case

study, my strongly held belief, based on experience and intuition, was that poetry could provide a means to that end.

Theoretical Framework

Critical Race Theory served as a lens for delving into this work. This theory expresses a need to challenge the status quo by examining, questioning, and rejecting practices that sustain intolerance and oppression. Solórzano and Yosso (2001, 2002) challenged the established system of tracking students according to performance on standardized assessments. As an antidote to this practice of tracking, and in order to challenge the dominant ideology that frames the traditional system of education, they proposed the idea of counter-storytelling to uncover cultural histories of students. In her work, Ladson-Billings (1995b) promotes a *Pedagogy of Opposition* that stresses three main points:

- a) students must experience academic success,
- b) students must develop and/or maintain cultural competence, and
- c) students must develop a critical consciousness through which they challenge the status quo of the current social order.

This theoretical stance emanates from a belief that a culturally relevant pedagogy is critical for a socially just education. The theory recognizes the significance of race as a factor in the inequitable practices that are manifested in the classroom. Berry (2003) has found that “although class is a factor in the achievement gap between African American and White students, race primarily accounts for the differences in mathematics achievement among these groups” (p. 245). Applying Critical Race Theory to educational research and to classroom practices underscores the need to provide all students the means to find and use their voices in order to participate fully in their education. This is

the conceptual frame that I explored as I continued working with students who struggle to achieve in settings that practice more traditional forms of instruction and assessment.

This frame allowed me to examine the variables that might help at-risk, marginalized students transcend the systematic cycle of failure to which they have long been subjected.

If, as Stange (2011) suggests, “the human aesthetic is strongly rooted in pattern and repetition,” (p. 1) perhaps the first step in challenging the normalization of failure that is embedded in the way we do school should be to examine other ways of teaching and learning and to establish new patterns of thinking. Reform begins and ends in the classroom (Garcia, 2010); it therefore seems most fitting to focus on impacting the classroom teachers through inquiry study. Knowing that the inability to succeed as mathematics students in the early grades might lead to a significant reduction in opportunities for a lifetime, I focused my research on the following questions.

1. How does teacher inquiry focused on mathematics instruction and culturally relevant pedagogy impact the attitudes and instructional practices of elementary teachers at a Title 1 school?
 - 1a. What changes, if any, do teachers report in their teaching of math throughout the inquiry process?
 - 1b. What connections do teachers in an inquiry group report between their study and their students’ ability to demonstrate mathematical understanding?

“You can't do the right thing until you stop doing the wrong things.”
(Diane Ravitch, 2011)

CHAPTER 2
THE BODY OF LITERATURE: POETRY, MATHEMATICS, CULTURALLY
RELEVANT PEDAGOGY, AND TEACHER INQUIRY

Introduction

The advent of No Child Left Behind legislation ushered in a wave of standardized testing designed to measure student achievement. This type of assessment has resulted in a narrowed focus on the achievement gap, which continues to grow ever wider between White students and students of color. African American students, designated a sub-group in assessment data reports, consistently score well below their peers in mathematics achievement; and race is considered a primary factor in the achievement gap (Berry, 2003). The purpose of this review of the existing literature is to identify factors that might contribute to the attitudes and instructional practices of elementary teachers that best support the success of all students in mathematics.

Schools with subgroups of low-performing students often resort to remedial methods of instruction focused on recall and repetitive practice, believing that these strategies will result in a narrowing of the achievement gap. Fullan (2003) as cited in Mintrop and Sunderman (2009) has shown that although targeting these students for standard-specific remediation can result in initial improvement in achievement, the effects of remediation are not long lasting. Student engagement in the learning process, supported by higher level thinking and problem solving, seems to better serve student learners and promote more long lasting effects; preliminary indications garnered through a pilot study begun in 2010 by Moore show that the introduction of poetry into

mathematics instruction may play a role in increasing student engagement and improving math achievement.

There is a great deal of literature that supports the use of non-standard instructional practices to strengthen student performance both in and out of the classroom. Because much of the research focuses on implementing a Culturally Responsive Pedagogy (CRP), I will explore this concept in depth. Tutak, Bondy, and Adams (2010) have found that CRP is not prevalent in mathematics education because of the common misconception that mathematics is a neutral topic, impossible to make culturally relevant. Gutstein (2006) calls for a major pedagogical shift to counter the prevalence of mathematics being accepted as apolitical and unconnected to issues of equity. The historically traditional perspective of mathematics has made it difficult for researchers, teacher educators, teachers, and pre-service teachers to conceptualize teaching and learning mathematics for social justice (Noyes, 2009, p. 207).

In chapter four, I will present research findings that propose re-visioning traditional math instruction to include culturally relevant experiences and perspectives of ethnically diverse students in order to teach more effectively. I will examine the inclusion of poetry and other linguistic devices as a culturally responsive method of instruction and I will tie it to the strengthening of math identity in African American elementary students through the process of teacher inquiry. In this review of the literature, I intend to present four distinct areas of research: poetry immersion, mathematics instruction, culturally responsive pedagogy, and teacher inquiry. I will then highlight the connections between these four areas to present a research foundation for a case study that focuses on the

attitudes and classroom practices of teachers at a Title 1 elementary school located in a suburban northern California community. By synthesizing the research, I hope to make a case for using teacher inquiry to study and design culturally responsive classroom instruction that best supports the learning needs of every student.

This research is designed to serve as a model of teacher collaboration focused on interrupting the marginalization of African American students and the intractability of math achievement. In a pilot study throughout the 2010-2011 school year, a group of teachers and I met every two weeks for several hours in a study designed and facilitated by me. We read research articles, examined student work, shared strategies, and observed and interviewed students. We introduced the reading, writing, and recitation of poetry into math instruction. The initial observations indicated increased participation and engagement of students, especially among African American boys. This observation is supported by the work of Muhammad (2003) who argues that math teachers can best capture the interest and energy of their students of color by incorporating different modes of learning, including poetry and music.

In our pilot study, we looked for patterns and behaviors that supported or challenged our assumptions. We agreed that we do not know what we do not know; I felt confident that if we kept our eyes and our minds open, the students would guide us, and they did. Thus, the purpose of this study, framed by this review of the salient literature, is to focus on the connection between words and numbers in order to design and to deliver culturally relevant mathematics instruction.

Empowering Voice Through Poetry

Poetry is when an emotion has found its thought and the thought has found words.
Robert Frost, 1874-1963

I have been an English teacher for more than 30 years and I have a passion for poetry. Again and again I have watched it transform the minds and hearts of students of all ages, ethnicities, and interests. Poetry is powerful; I believe strongly that it can change lives, a belief borne out in my classroom observations and in the testimonials of many other teachers and researchers. Over the years, others have chronicled the impact that reading, writing, and reciting poetry can have on young people, and I will highlight some of the most interesting of these studies in this section. These particular studies supported and fueled my work with continuation high school students and have helped build a bridge to explore the power of poetry in elementary mathematics instruction.

Stovall (2006) employed a participatory action research methodology as he studied the work of four poetry educators with inner-city, disenfranchised youth. He provided critical insights into how creating and performing poetry might support the educational process. Stovall's ethnographic account of his involvement documents the belief systems and the instructional practices of his four subjects as they use poetry to teach social justice, and it chronicles the empowerment of the youth as they are schooled in the practice of poetry with a social justice agenda. The focus of this work was on awakening commitment, voice, power, and action in underrepresented youth and awakening a commitment to a social justice agenda in the research community. Stovall's participatory action project stressed activism and the rooting out of racism in urban youth

culture. The students highlighted in the article were challenged and changed by their exposure to the world of poetry and performance. Stovall (2006) conducted his research through interview, observation, and participation, concluding that “social justice in education remains a broad but necessary concept” (p. 79) that can be effectively taught through poetry.

The themes of silence, resistance, racism, and empowerment were explored by Weiss (2009) in a chapter entitled, *Theory and Educational Research: Toward Critical Social Explanation*. The author advocated for change by portraying a system of one-sided power in the educational construct, resulting in students who are silenced. She used writing in much the same way the oppressed have used it throughout history, as a vehicle of protest. In this case, she was working with students who were galvanized to protest the oppressive surveillance that was part of their reality in an urban secondary school by staging a walk-out. A small group of students organized a poetry club soon afterward, realizing that their protest did not bring about the change they had hoped for. These students instead used writing to connect, to communicate, and to protest in a different way. Weiss was guided in her work by theories of de Certeau and Scott and the phenomenon of youth resistance, especially youth resistance to policing, through literacy. Weiss used the poetry that students wrote to protest school surveillance as a data source; she then used this data to collect more qualitative accounts, including student interviews, in order to more deeply understand the power of writing and political action.

Weinstein (2009) devoted an entire book to exploring the lives of inner-city youth who define themselves through their writing outside of school. These students refuse to

write in school, yet are prolific outside the confines of the classroom. The author presented an educational conflict: teacher-centered classrooms and standardized curricula that devalue student choice, adolescent voice, and engagement. She posed a powerful question: how can it be that students with so much to say and so much motivation to share their voices have so little social capital within the school walls? Weinstein also addressed the tension that exists between nurturing a student's writing fluency and their learning the language of power. By sharing the stories of nine young writers from Chicago, Weinstein was able to show the rich, intellectual writing lives of students who were otherwise disengaged from standardized literacy discourses and to call into question mainstream educational practices. This book does not provide recommendations for how these stories might be helpful to educators other than to encourage them to question their assumptions about the students in their classrooms.

In 2009, Knaus used his work with urban continuation high school students to explore the instructional techniques that encourage student voice by applying critical race theory to his classroom experiences. By using his own impoverished background and the stories of several students, he illustrated the plight of many disenfranchised students. He held a mirror up to his own teaching practice and, rejecting the mainstream curriculum, described the ways in which building trust through shared stories increased participation in school and in the world. In the classroom, Knaus shared his own painful stories of growing up and built a classroom community in which students were comfortable sharing stories of violence, gangs, trauma, and anger. He argued that students who attend under-resourced urban schools, like the continuation high school where he teaches, are

“provided with standards-based education, young teachers with little prior experience, often no stated dedication to their communities, and no real training or tools” (Knaus, 2009, p. 138) to deal with their realities.

Knaus (2009) demonstrated that applying critical race theory to the classroom makes an impact on students of color by increasing engagement and allowing students to develop their voices and their academic engagement. Knaus’s article provides educators tools for working with students in meaningful ways by acknowledging the varied emotions and experiences that all students bring to the classroom. The article demonstrates instructional techniques that encourage student voice as a foundation for academic excellence, and argues that applying critical race theory ultimately requires re-visioning the entire American educational system. Knaus (2009) was very much a participant in his action research, and he framed his argument in the history of Critical Race literature.

I have certainly deepened my understanding of the role of poetry in working with marginalized youth, and I have seen its power firsthand. In addition to the researchers mentioned above, the body of work of Ladson-Billings (1995ab, 1997, 1999), Morrell (2002), and of course, Freire (1970), contributed to building and supporting my theoretical foundation. I have been inspired by what poetry educators/researchers like Jocson (2006) and Hall (2007) have to say about the power of language to change lives. In my work in suburban schools, I have seen quite a bit of marginalization and oppression as well, and I believe there is much to be gained by concentrating my work on students in the high-achieving, college-bound suburbs. There is limited literature directed at students

in these environments, and a dearth of research that supports the development of these students' voices, especially regarding mathematics achievement. This study aims to add richness and texture to the literature by focusing on an under-represented population, struggling students of color in a high-performing school district.

These studies explored the transformation that takes place when students are taught to take poetry seriously; through this process they begin to take their lives seriously. Although the researchers presented here focus on older students and the poetry they studied focused almost exclusively on a social justice agenda, there is much to learn and apply to the elementary classroom. This poetry immersion contributed to changing the study participants' self-perception. My intent was to explore a theoretical stance which would suggest that enriching the elementary mathematics curriculum with the rhythm and language of poetry would lead to an increase in student engagement and participation. This increase could, in turn, strengthen students' mathematics identities and increase mathematics achievement.

This theory was the driving force behind the formation of the Title 1 inquiry study group that researched alternative ways of supporting and improving the mathematics performance of its African American boys. It has been well documented that the rich cultural heritage and oral tradition of African Americans is rooted in an affinity for rhythm, rhyme, and pattern; these are some of the shared attributes of poetry and mathematics.

The Poetry of Mathematics

*It is often said that mathematics resembles poetry.
We argue that some works of mathematics are in fact poetry.*

James Henle, 2011

Berry, Thunder, and McClain (2011) found that the development of a positive mathematics identity is essential towards helping African American boys develop and sustain an interest in mathematics. Tate (1995) suggested that the failure of traditional math instruction to take into account the experiences, culture, and traditions of African American students plays a major role in the inability of African American students to perform successfully on traditional math assessments. His research provides a rich historical perspective on mathematics education and he argues that because African American students are more likely to be tracked into remedial math than White students, their educational opportunities are limited: they are therefore ill-prepared to use mathematics in order to negotiate the complexities of the democratic process. Mathematics instruction that adheres solely to traditional, Eurocentric ideals prevents African American students from fully participating in the world, according to Tate (1995), and he presents an argument for placing African ideals at the center of mathematics instruction, a practice that he refers to as Africentricity.

Closely related to Tate's (1995) challenge of the way that mathematics is traditionally taught and tested, Berry et al. (2011) challenged the "dominant discourse in the mathematics literature that hold African American students' mathematics achievement as deficient and White and Asian students mathematics achievement as the standard for success" (p. 11). While these three researchers do not propose building a

totally Africentric curriculum as does Tate (1995), they do propose offering a challenge to the master narrative through counter narratives that present African American students as mathematics learners.

Similarly, Berry (2003) argued that African American students have been underserved in the mathematics classroom. He stressed that in order to improve mathematics achievement, teachers must help students make connections between their cultural experiences and knowledge and mathematic structures. Gadanidis and Borba (2008) presented an interesting offshoot of this thinking, focusing on a more emotional and aesthetic experience of solving mathematical problems. They urge math teachers to shift their pedagogical paradigms and begin to see mathematics education through the lens of performance. Their work with the Social Sciences and Humanities Research Council of Canada has focused on a more interactive and interpretive process of instruction that allows students to be more fully engaged in building an understanding of mathematics.

Much of the research that deals with student engagement in math touches on the notion of mathematics being an educational gatekeeper. Denying access to an advanced curriculum is often determined through ability grouping in the early grades, a phenomenon that denies power and position to those who do not master the subject. Stinson (2004) argued that this has been the case throughout history, beginning with Plato's *The Republic*. In more recent history, according to Stinson (2004), ability grouping of students has led to the exclusion of students of poverty and color in advanced mathematics courses, and this inequitable practice has become a rallying cry for

educational reformers. His argument explored the need for reform not only in the teaching of mathematics, but in the very way it was used as a deliberate tool for societal stratification. Like many of those calling for reform, Stinson cites Friere (1970) and the connection that he made between literacy and mathematics; this connection hinges on the understanding that a strong math identity can indeed allow students to reword their worlds.

Poetry and Mathematics Connection: Building a Culturally Relevant Pedagogy

Everything one invents is true, you may be perfectly sure of that.

Poetry is as precise as geometry.

Gustave Flaubert, 1821-1880

Nearly 20 years ago, the National Council of Teachers of Mathematics made a recommendation that the math curriculum be expanded to include reading, writing, and oral language (Grossman, Smith, & Miller as cited in Kolstad, Briggs, & Whalen, 1996). Making the connection between language and symbolism and mathematical relationships was deemed a necessary part of mathematics instruction. This logical intertwining of words and numbers to deepen understanding has not taken hold in most math classrooms, but the following research articles highlight the socially just reasons for doing so.

The majority of remedial math classes being disproportionately comprised of African American students is not an issue that is unique to urban schools; this trend is also evident in high-performing suburban school settings. Current research indicates that this phenomenon is widespread, and National Assessment of Educational Process data reveals that math proficiency continues to divide disproportionately along racial lines (Berry, 2003). Moses (as cited by Ladson-Billings, 1997) argued that mathematical

literacy is a civil rights issue manifested in the gatekeeping role that algebra plays in tracking African American students into decreased educational and economic opportunities. The truth is that math functions as a gatekeeper in higher education, and the achievement gap continues to plague many of our public schools, no matter the community. Therefore, it is important to explore teacher attitudes and instructional strategies that might lead to an interruption of this practice. Studying the impact of teacher inquiry focused on culturally relevant pedagogy and mathematics instruction may help to shed some light on the topic and contribute to the conversation on more equitable math instruction.

In her review of two contemporary texts, *Reading and Writing the World with Mathematics: Toward a Pedagogy for Social Justice* and *Rethinking Mathematics: Teaching Social Justice by the Numbers*, Adair (2008) focused on a position of advocacy for embedding the tenets of social justice into the mathematics curriculum. In the article, the author sets her argument alongside Freirian philosophy and contemporary critical theorists. It is a wonderful introduction to further study around the role of social justice pedagogy in the content areas. This is particularly relevant given that a question raised by my colleagues in our preliminary study is, “Why do we continue to assess students in such narrow ways?” This is virtually the same argument that Schmoker (2011) made when he asked why we continue to pretend that teaching algebraic thinking connects to real-world mathematical skills. He stressed that as the level of abstraction increases in the math curriculum, meaning drops off, followed by a drop in motivation and comprehension, the result of which is failure. It does not have to be so.

Adair (2008) framed her discussion of the two books with three relevant questions, and she gave examples from each text to show how the authors applied a social justice pedagogy to their mathematics instruction. In this review, she also poked holes in some of the assumptions made by the authors, and raised a most intriguing observation about the missing elements of Freire, namely the absence of community in the educational process and the lack of reference to how teaching social justice might change teachers. By using the explicit examples from the authors' classrooms, Adair gave educators strategies and reasons to teach mathematics through the lens of social justice.

Altieri's (2009) work presented a variety of literacy strategies to help elementary teachers reinforce students' mathematics knowledge, but it does little to further an understanding of the role that poetry can play in deepening and internalizing mathematical concepts and comprehension. In the early studies conducted by the pilot study group I facilitated, we realized that although students were engaged in the singing of the math rhymes, they were not transferring the knowledge to their work. Altieri shared a number of literacy strategies such as word associations and games that can play a role in supporting engagement in the math classroom, but the theoretical piece is insufficient. It is easy, however, to imagine using an article like this in order to spark the interest of elementary teachers; this could serve as a stepping stone to thinking about the role of literacy in general and poetry in particular to strengthen the math curriculum.

Instruction Matters: Teacher Inquiry and Culturally Relevant Pedagogy

Culturally relevant teachers utilize students' culture as a vehicle for learning.
Gloria Ladson-Billings, 1995a

Devlin (2001) argued that once one has a deep understanding of mathematics and can see how to pair that knowledge with understanding how language is created, it becomes clear that mathematical thinking is just a specialized form of language facility. In Minton's (2007) book, *What If Your ABCs Were Your 123s?*, the author illustrated the parallels between literacy and mathematics and helps elementary teachers take what they know about teaching literacy and apply that knowledge to strengthen their math instruction.

Boykin (as cited in Berry, 2003) used his research to define the cultural experiences of the African American community including oral tradition, performance, movement, rhythm, and pattern. In this same article, Ladson-Billings' (1995a) research is cited in a discussion of culturally based mathematics instruction that reflect African American influences of rhythm, pattern, and poetry. In earlier work, Ladson-Billings (1995a) discussed the role of the teacher in promoting culturally relevant learning experiences, presenting as an example a second grade teacher whose students scored high on standardized testing despite the fact that their study of poetry was delivered through the vehicle of rap music. Ladson-Billings (1995a) cited this as an example of how academic achievement and cultural competency can work together. This is important to note, because as Hunter and Bartee (2003) pointed out, standardized testing equates educational outcomes as a measurement of intellectual ability and equates educational

differences as educational deficits. The implications from Ladson-Billings' study suggest that it is possible to teach in a way that is culturally responsible and academically sound.

In her work with English Language Learners, Bicais and Correia (2008), noted that "children perform better when academic tasks are meaningful and culturally relevant," (p. 363) and that teachers must take advantage of the many opportunities that they have to build this understanding into their teaching practice, an idea that is substantiated in numerous studies on teacher efficacy. Two such studies focused exclusively on the role of teacher inquiry into children's mathematical thinking and classroom practice. A study of the role of research-based knowledge of teacher beliefs and practices and the resulting positive impact on student achievement in mathematics (Fennema et al., 1989), explored the development of a framework for assessing teacher knowledge and student achievement. The findings from this study laid the groundwork for subsequent studies on the link between teacher attitudes and expectations and the performance of their students; this underscores the importance of providing relevant, targeted instruction that allows students to be successful.

Steinberg, Empson, and Carpenter (2004) identified three specific conditions necessary for a change in teacher belief and practice: membership in a discourse community, explicit processes employed that support honest conversation and reflection, and ownership of the resulting process of change. An interesting discovery made by this research team, and one that has critical implications for groups involved in teacher inquiry, is that at the end of a cycle of inquiry, some teachers are unable to sustain or continue applying their new knowledge about teaching and learning. The research team

concluded that ongoing learning through practice and collaborative study is an essential mechanism for reform.

The pilot inquiry study group that I organized at one of the only Title 1 schools in a large, high-performing suburban school district, consisted of a kindergarten and third grade teacher, two fifth grade teachers, a literacy coach, the principal, and me. Our focus was on the achievement gap, particularly in math. In addition to observing students in four classrooms and looking at baseline data, we watched videos that used rap and rhyme to learn math concepts, we interviewed a number of our lowest achieving math students, we read a number of articles and studies, and we shared ideas for engaging math students in more unconventional ways. Potential findings and our yearlong conversation was promising. One of the interesting insights from the third grade teacher provided us with a potentially interesting concept to explore. She mentioned that even though she had infused music, chants, movement, and poetry into all her teaching, resulting in increased participation and performance in the classroom, her achievement gap students did not show growth on formal math assessments. This underscored what many research studies concluded, and it raised many questions that I wanted to pursue further.

Understanding that this was a topic that called for further in-depth study, I constructed a dissertation design that would focus on how teacher attitudes and practices were impacted by their exploration of the infusion of poetry into elementary mathematics instruction. As my colleagues and I continued to work together, we continued to call into question the traditional system of mathematics education and the imbalance of power it perpetuates, and to look for instructional strategies that best support all students.

All students need literacy, numeracy, technological, social and political skills in order to be active participants in democracy.

Ladson-Billings (1995)

CHAPTER 3

METHOD: A TEACHER INQUIRY MODEL FOCUSED ON CULTURAL
RELEVANCY, LESSON STUDY, AND INSTRUCTIONAL PRACTICES IN
MATHEMATICS



Introduction

Schools with subgroups of low-performing students often resort to remedial methods of instruction focused on recall and repetitive practice, believing that these strategies will result in narrowing the achievement gap. Fullan (2003) as cited in Mintrop and Sunderman (2009) has shown that although targeting struggling students for standard-specific remediation can result in initial improvement in achievement, the effects of remediation are not long lasting. Student engagement in the learning process, supported by higher level thinking and problem solving, seems to better serve student learners and promote more long lasting effects; preliminary indications garnered through a pilot study begun in 2010 by Moore show that the introduction of poetry into mathematics instruction may play a role in improving math achievement.

This proposed study was framed as a case study designed to investigate the impact of teacher inquiry on the attitudes and practices of classroom teachers. Creswell

(2007) explains that the case study design explores a program, event, or individuals by means of a case (or cases) bound by time, using multiple sources of data (p. 15). Teachers were offered resources to investigate instructional strategies that take into account the cultural expressions of their students (Leonard, Brooks, Barnes-Johnson, & Berry, 2010). Using poetry, rhyme, and rhythm to introduce, teach, and reinforce mathematical concepts, five classroom teachers representing grades kindergarten through four, conducted assessments and gathered evidence through student conferences and artifact collection. It was theorized that teacher observations and conversations could lead to the uncovering of additional instructional strategies to implement. The teacher inquiry group discussed the evidence gathered with their colleagues within the group; these discussions were audiotaped, transcribed, and coded by this researcher.

Articles, lesson plans, math poems, and other relevant resources were housed in an on-line Dropbox for the inquiry group participants (Dropbox is a Web-based file-hosting service operated by *Dropbox, Inc.* that allows users to store and share files and folders with others across the Internet.) As the researcher, I set up the Dropbox folder labeled “Nature Refuge Math Inquiry” and invited the participants to join so that they would have easy access to a variety of resources; they, in turn, were able to add resources that they found interesting and supportive of our work. Transcripts of the inquiry group meetings were also uploaded to the Dropbox immediately after each session so that participants were able to revisit previous conversations and correct any inconsistencies in intent or meaning.

This research was designed as a qualitative research study. Teacher responses on a self-assessment continuum given at the beginning and end of the study, running from mid-August to mid-December 2011, were analyzed and coded, as were the transcripts of the regularly scheduled, facilitated inquiry study sessions. Because the study was designed to evolve from the data collected, it relied on grounded theory as well as the theory of Culturally Relevant Pedagogy.

*Open up.
Let one eye watch
the parallels
that meet.
Shift to a point
of perspective.
Draw those lines
that cross
at your heart.
(Growney, 2010)*

Site of Study

This study was conducted at a Title 1 school (Nature Refuge Elementary, or NRE) that serves a diverse population of students in kindergarten through fifth grade. The school is in a newly constructed neighborhood in a large, high-performing, suburban K-12 district in northern California. The school has grown from an initial population of 141 students in its 2005 opening to nearly 1,000 presently enrolled students. The rapid growth of the community actually forced the school to open a year ahead of schedule, existing that first year in portable classrooms housed on the playground of another elementary school a few miles from its eventual home. NRE is presently faced with the prospect of adding additional portable classrooms to its campus due to the continued, unanticipated growth of the surrounding new community.

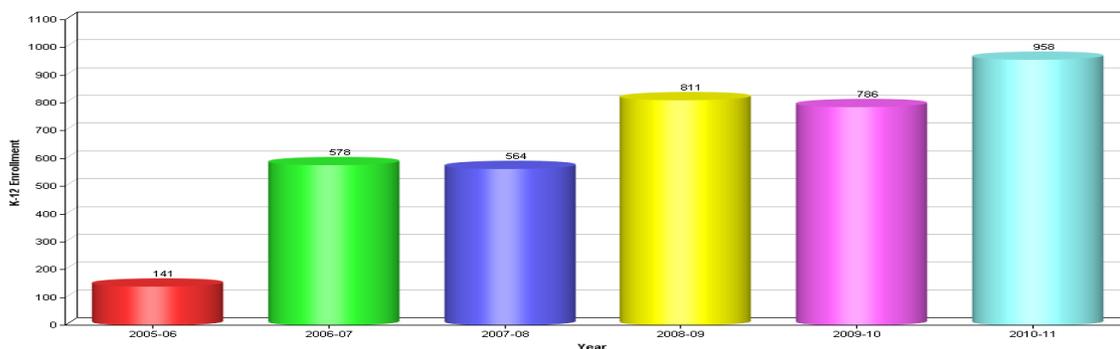


Figure 3.1. Rapid Growth of Nature Refuge Elementary (NRE).

Due to changing demographic growth patterns including an increase of immigrant families and construction of Section 8 housing, the population at NRE is considerably more diverse than at the other schools in this high-performing, suburban community.

School	Hispanic or Latino of Any Race	American Indian or Alaska Native, Not Hispanic	Asian, Not Hispanic	Pacific Islander, Not Hispanic	Filipino, Not Hispanic	African American, Not Hispanic	White, not Hispanic	Two or More Races, Not Hispanic	Not Reported	Total
Nature Refuge	78	2	531	4	52	59	167	65	0	958

Figure 3.2. School Population Demographics at NRE.

For example, while in 2010, more than 54% of the district's nearly thirty thousand students reported their ethnicity as White (California Department of Education, 2011), at NRE the reported White population is 17%. NRE also houses the largest number of special education students of any district school. Because of this, the staff is acutely aware of serving the needs of all students; the school mantra is, "All our kids are all our kids." During my time working with teachers at NRE, I heard this repeated often.

Additionally, as part of their continued professional development, teachers are encouraged to read articles and form study teams that address issues of diversity and inclusion, and to share their learning in both formal and informal settings.

Study Participants

The participants are tenured teachers representing grades kindergarten, first, second, third, and fourth at a Title 1 elementary school in northern California who volunteered to participate in this research. For the purpose of this study they will be referred to through the following initialed pseudonyms: RB, LK, KHJ, IR, and NS. Of the five participants, all are female. One teacher identifies as South Asian, the other four identify as White (one teacher further identifies White as Persian, and another as Slavic). They range in age from 30 to 50 years old. Two of these teachers took part in a pilot study with me during the 2010-2011 school year; they expressed an interest in continuing to explore mathematics achievement and instructional practices through an inquiry study group. The other three teachers were part of a study team exploring culturally responsive teaching at the school the previous year. They joined this inquiry study team at the suggestion of Principal CL, an advocate for social justice work, and an admirer of their advocacy work on behalf of their students.

Throughout the course of the previous school year, trust was built among participants as they shared a commitment to equity work, and a desire to help all students achieve success. All five participants expressed an interest in exploring this work focused on introducing poetry into mathematics instruction as a form of culturally relevant pedagogy. Although it did not seem to be a concern for the participating teachers, I

assured them that their identities would be protected through a system of coding and anonymity assurance. They were told they could elect to withdraw from this study at any time without repercussions.

The inquiry study group also participated in lesson study through a Northern California Math Coalition (NCMC) during the course of our work together (this group title is also a pseudonym). Although it was not originally our focus, NCMC became a natural extension of our inquiry. The Northern California Math Coalition is a comprehensive effort designed to improve mathematics instruction and student learning. The work of the coalition is to model high performance expectations, provide ongoing professional development, examine student work, and foster improved math instruction. Being affiliated with the coalition appeared to strengthen the line of thinking we were already pursuing in our inquiry study, and teachers agreed to share their growing understandings through collaboration sessions that I facilitated as teacher/researcher. The school principal participated in the group whenever her schedule allowed. She has a congenial relationship with the staff and based on my frequent, informal observations, I believed her presence was unlikely to skew the data.

Positionality of the Researcher

My role was that of teacher/researcher. My position in the district is that of Teacher on Special Assignment, a designation that means I have been released from classroom duties to support teachers and provide professional development, but my role carries no more weight than that of a traditional classroom teacher. I am not considered an administrator and do not evaluate teachers. I surmised, however, that because I

generated this inquiry study and because I am housed at the district office, it would initially be possible that participants would perceive our relationship as lopsided. If so, this perception of status inequity might have resulted in the participants feeling a slight sense of coercion to respond accordingly, or a desire to please the researcher. I resolved to remain vigilant of this throughout the process, and did not identify any instances where this was evident.

The presence of the principal in some of the sessions could have also caused a similar affect although she is seen as a staunch supporter of these teachers and this project. I checked in with participants regularly to assess how they were feeling. Based on my observations of them in our frequent meetings and on the collaborative school climate, I did not anticipate the participants feeling undue pressure; I did, however, make it clear that they were free to withdraw from the study at any time without fear of retribution.

The case study participants were surveyed, interviewed, and observed in their collaborative group setting. Artifacts, such as students' math notebooks and formative and summative assessments, were analyzed by the teachers. All conversations were recorded, coded, and analyzed by this researcher.

The Faculty Participants

RB is teaching fourth grade this year, most of her current students were in her third grade class last year and elected to "loop" with her this year. She has been a public school elementary teacher for the past 12 years and previously studied with Dr. Sharroky Hollie at the Center for Culturally Responsive Teaching and Learning in Los

Angeles. Although she is White, she grew up with an African American sibling. She indicated at the onset of our study that she was most interested in discovering how her teaching can be informed and improved by talking openly and honestly about race. She was a member of the pilot study group last year, and also participated in a Northern California Math Coalition Lesson Study Group two years ago.

LK is teaching third grade this year after several years teaching kindergarten. She too was a member of last year's pilot study with me. She is currently completing her Master's degree focused on integrating the arts into the curriculum. LK was quite enthusiastic about the integration of poetry into her teaching, and her students composed poems for two voices to accompany each math unit that she taught throughout our research.

NS grew up in New York and began her teaching career there as well. She has taught middle school and primary grades in her nine year teaching career. Her first experience in California was in a more urban setting. She has been teaching first grade at NRE for the past three years, and her children attend school here as well on an intra-district transfer due to her belief in the nurturing academic and social culture of the school. Originally from the Middle East, NR grew up very aware of racial inequity, and she considers it a personal mission to educate against biases.

Prior to teaching at NRE, IR taught at a private school in a neighboring community. This is her sixth year as a teacher, and she has taught exclusively at the first grade level. She grew up in Sri Lanka and was surprised and embarrassed to discover that one of her students is also from Sri Lanka, as neither he nor his parents revealed

that fact in any of their encounters. She has expressed a level of discomfort when talking about race.

KHJ is in her seventh year of teaching. She attended kindergarten through high school in the school district in which she now teaches; her mother was a teacher in this district as well. Prior to teaching at this school, she taught in a large suburban school district in southern California. Her teaching experience is exclusively in kindergarten and first grade.

Additional participants in some of the debrief sessions were OT, a teacher on special assignment; CL, the school principal; MM, a director of curriculum and instruction who was visiting the campus during the lesson study process, and Dr. Dora Dome, an outside professional development provider hired by the principal to raise awareness on personal biases and anti-racist language. The inquiry group's thinking and many of our discussions throughout the study were also informed by the work of the following education specialists that I conferred with during the course of this study:

GD (Assessment TSA, high school math)

MK (Math TSA, middle school math teacher)

RD (Literacy TSA, middle school core teacher)

Dr. Jeanette Bicais (Dissertation Chair)

Dr. Margaret Harris (Dissertation Committee Member)

Dr. Matais Pouncil (Dissertation Committee Member)

Ms. Dora Dome, JD (Outside PD Provider)

Dr. Nancy Dome (Outside PD Provider)

Dr. Keith Devlin (Stanford Researcher/Presenter)

Timeline: Milestones in the Inquiry Process

The timeline below represents the major milestones along the way during the research I conducted on the impact of culturally relevant pedagogy and mathematics instruction on the attitudes and practices on a group of teachers at NRE. Although I stopped collecting data for the purposes of this study in mid-December 2011, the end of data collection did not signal an end of the collaborative work of the group. We continued to study together and share our findings with other groups throughout the remainder of the school year.

Date and time of meeting	Participants (in addition to researcher)	Purpose/Context
August 23, 2011 3:00 – 4:00 pm	NRE Staff, Dora Dome, Nancy Dome	“The Tragedy of Non-Ness” professional development focused on language and culture
September 15, 2011 6:00 – 8:00 pm	Dr. Bicais, Dr. Harris	Chapter 1,2,3; proposal approval
September 20, 2011 all day	LK, RB, Northern California Math Coalition Participants	Understanding lesson study Professional development seminar
September 29, 2011 3:00- 4:00 pm	Inquiry Study Group	First suggestion of incorporating poetry into math instruction
October 6, 2011 3:00- 4:00 pm	Inquiry Study Group	Schedule developed for lesson study process Common misconceptions
October 18, 2011 3:00- 4:00 pm	Inquiry Study Group, CL	Number sense discussion
October 31, 2011 8:00-3:00	NRE Staff, Dora Dome,	“Let’s Talk About Race” professional development focused on examining cultural biases
October 31, 2011 3:00 – 4:00 pm	Inquiry Study Group	Review of notes from October sessions, sharing student- generated poetry
November 16, 2011 11:00-12:00 noon	Researcher, MM, RD, MK, GD	Observation of Calculus Lesson using literacy instruction
November 26, 2011 10:00-11:00 am	Dr. Pouncil	Progress report on dissertation
November 29, 2011 4:00-5:00 pm	Dr. Bicais	Progress report on dissertation
November 30, 2011 all day	Inquiry Study Group	Planning “dirty” math lesson using <i>This Plus That</i>
December 8, 2011 all day	Inquiry Study Group	Prebrief, lesson delivery, debrief, revision of lesson
December 15, 2011 8:00- 11:00 am	Inquiry Study Group, MM, CL, OT	Prebrief, lesson delivery, debrief
December 17, 2011 2:00-4:00 pm	San Jose Tech Museum	Keith Devlin lecture on The Birth of Algebra at San Jose Tech Museum

Figure 3.3. Timeline of the Study.

Data

The types of data collected include teacher self-assessment rubrics calibrated along a continuum of teaching practice, transcripts of teachers' reflective conversations, classroom observation and conference notes provided by the teachers, researcher field notes, and student artifacts such as notebooks, assessments, and homework. The teacher self-assessments were completed in my presence, and I recorded the participants' oral commentaries in addition to collecting and analyzing their written self-assessment documents. Student artifacts were gathered on a regular basis by the classroom teachers. Teacher interpretations of the student work were included in the data.

Data Analysis

I took field notes and transcribed the conversations that took place inside the inquiry study sessions. I looked for trends and patterns, and coded the teachers' remarks. This analysis was examined in conjunction with the teachers' self-assessments on a continuum of teacher practice (see Appendix A).

Coding

I spent the week of winter break steeped in the world of transcription. I had a total of 11 hours of audiotapes from my sessions with the inquiry study group, which I spent 40 hours transcribing. I chose to do all the transcribing myself rather than use a service and I am glad that I did. Listening to the tapes, paying attention to what was said, how it was said, where the pauses were, when there was a reaction (like laughter), really helped me to make sense of the inquiry process. It also helped me to closely study my role as researcher and facilitator.

As the facilitator, I realized that sometimes I made strategic moves to propel the conversation in a certain direction, but I also realized as I listened again to the tapes and read back over my words, that I was being transparent in most instances, making the participants aware of those moves by explicitly naming them as they occurred. An example of this took place in a session early in the process as I recapped the previous session's discussion for the group:

And so then we started talking about what things we might be able to do to kind of build a math identity using things that were exciting. And at the end of our time together we kind of lit on the idea of poetry. Which is something that I had kept coming back to and so I'm sure that probably had something to do with like, *Ooh! Poetry!* Because I kept saying, *What about poetry? What about poetry? What about poetry?* (K. Moore, personal communication, October 31, 2011) (laughter)

The process of making sense of the work that we did together, and the impact that the work had on teacher attitudes and practice was challenging, enlightening, and inspiring. As a researcher, it confirmed some theories I had made about the importance of inquiry as well as the collaborative process. More importantly, for me, the research raised many more questions than it answered, and it led me down paths I do not believe I ever would have travelled. Through this process, I learned as much about myself as I did about the subject I had set out to study.

...praise song for walking forward in that light
(Elizabeth Alexander, 2008)

CHAPTER 4

RESEARCH FINDINGS

Making Meaning

This participatory research case study took place over a four-month period in the fall of 2011. As a teacher/researcher, I designed the study, facilitated the group discussions, and because it was participatory research, I was directly immersed in the inquiry process along with the five classroom teachers. The participants are tenured teachers representing grades kindergarten, first, second, third, and fourth at a Title 1 elementary school in northern California (NRE) who volunteered to participate in this research. For the purpose of this study they will be referred to through the following pseudonyms: R. Braverman (RB), L. Konnigsberg (LK), K.H. Joyce (KHJ), I. Reedy (IR), and N. Strong (NS).

I suggested articles for the participants to read and I introduced several additional resources for consideration; the participants were encouraged to do the same. Throughout the study, the participants added research articles, math picture books, website links, and math poems to our growing body of knowledge; these resources continued to inform our work. In addition to those resources housed in an on-line Dropbox account that I initiated, the school librarian provided a shelf in the library to house our growing collection of picture books, poetry books, and professional texts. These resources were shared during our sessions and were available to the teachers for check-out between sessions.

We met as a team in several after-school sessions as well as in half-day and full-day sessions made possible through a grant from a group that I will refer to as the Northern California Math Coalition (NCMC). This grant permitted the purchase of professional texts and funded the salaries of substitute teachers, allowing the participating teachers to schedule release time from the classroom. As I will detail later in this chapter, this release time played a critical role in the development, structure, and power of the inquiry study.

Each session was audio recorded, reviewed by me, and available to the teachers for review. Immediately following each session, I would listen to the audio recording of the session and reflect on the conversation, taking notes and positing some preliminary theories about the nature of the study, the roles of the participants in building a shared understanding, and my role in shaping the study. I noted the number of times each participant spoke, the nature of the comments, and the pacing and tone of the conversation. In these first-listens, I was especially aware of the points at which I would interject, and the framing of the questions I asked that served to move the conversation along. It was in these initial listens that I became aware of my tendency to invite agreement with the direction the conversation was moving and to articulate this for the group. For example, throughout the transcripts there are several instances where I would lay out a thought in the direction I wanted to move the conversation followed by *right?* Here are three different examples of that from an after-school session in October, in the early stages of the inquiry group study.

- Researcher: Like, to think about listening to math for the poetry. Like what a paradigm shift that is, right?
- Researcher: So we want the students to be able to show us something that's challenging and complex, but we want to find a simple way to have them demonstrate that, right?
- Researcher: We need to something concrete, right?

Because of this awareness, I was conscious of the role I played as teacher/researcher in the study from the outset. I was able to see the effectiveness of strategies I used as facilitator and I believe as the study went on, my conversational moves became even more direct and purposeful. I believe I also began to understand the different strengths each participant brought to lesson planning and lesson study and to let the work evolve in a more organic fashion.

During the data collection, in addition to the recorded inquiry sessions with the teachers which chronicle the evolutionary scope of this work, I kept a field notes journal which contributed to my understanding. Additionally, the teachers filled out an assessment rubric along a continuum of cultural proficiency at the beginning and at the close of the study; I considered these as an additional means of gauging their growth and attitudinal shifts throughout the process.

When the data collection phase of the study ended in mid-December, I devoted an entire week to listening to the tapes again in chronological order, and transcribing the conversations. I had recorded eleven hours of teacher talk which took more than 40 hours to transcribe and resulted in 89 pages of typed transcript to code and analyze. I realized the complexity of the process, and because I had had prior experience in transcribing talk, I was well aware that initial understandings often give way to more layered and nuanced

understandings. I began the coding process by highlighting text in three different colors based on three components that I expected to find:

- Yellow: poetry, language
- Blue: math, numbers
- Green: culturally responsive pedagogy

These were the topics that informed my literature review, and it seemed like a very safe place to start. Once I had gone through all 89 pages of transcribed notes, I began the next phase of the coding process, annotating the highlighted passages. At this point I was just putting into words my first impressions and interpretations, knowing that I would go back to the text again and again to analyze more deeply as patterns emerged and my perspective shifted.

Identifying the Issues

There were three major issues that emerged as the inquiry group progressed throughout the lesson study process, and not surprisingly, these were three issues that emerged in the initial coding of teacher talk.

Issue one. Students who struggle early in math continue to lag behind their peers and are unlikely to reach higher levels of mathematical understanding, or to participate in the type of math coursework that would allow them to have an equal chance in life. Since low-level computational skills have little connection to critical thinking and mathematical knowledge, math instruction must be rigorous, robust, and accessible to all students (Tate, 1995; Devlin, 2011). Greater opportunity to advance and compete in career, college, and community environments comes from early success in algebra; it is a necessary tool for advancement in modern society.

The teachers at NRE recognized that even their seemingly successful math students were at risk mathematically. They indicated that many students were strong in computational skills and math fact retrieval, but showed limited ability to demonstrate an understanding of the mathematics behind the algorithm. They indicated that this phenomenon is a cause of great concern and it was a major factor contributing to our study of math through the lens of poetry.

So, one of the reasons that we're doing it that I heard everyone say is because we notice that our students memorize facts, basically they're good at memorizing, but not at seeing patterns (L. Konnigsberg, personal communication, November 30, 2011).

Issue two. Students, teachers, and the culture of school all seem to refer to math in isolation. Early on in this research study, the participating teachers discussed their frustration with the inability of their students to recognize the richness of math in their lives, to see it only in the context of math class time. One particularly valuable exchange took place in November as the group discussed the purpose of the lesson they were in the midst of designing. This exchange led shortly thereafter to the design of the lesson study lesson that fashioned the bulk of our work together.

They're good at memorizing but not at explaining their thinking, they're not good at articulating the process (N. Strong, personal communication, November 30, 2011).

Uh-huh. There you go. They're strong in computation, memorization, but struggle in articulating the process and explaining their thinking. (R.

Braverman, personal communication, November 30, 2011)

Researcher: Is there a place here, too, to talk about how students see math as such an isolated activity?

Definitely. Yeah, that's key (R. Braverman, personal communication, November 30, 2011).

Students see math in isolation rather than the broader context of life.

Students see math in isolation rather than contextually. Well, really, we need to look at math differently. We keep saying this, math is all around us, math is all around us. Math is art, math is science. I think I learned it in isolation, we all learned it in isolation and it's not that. We know the world is getting smaller, we know that math is a big part of it. Growing up, it was what's the answer, never how did you get the answer (N. Strong, personal communication, November 30, 2011).

This conversation led to a discussion of the teachers' role in this equation, and the fact that they taught math in very narrow, isolated chunks of the school day. Later on in the study, when we were designing a lesson to teach first graders, we came back to this idea, and the revelation that strategies like partner talk that teachers used effectively in other parts of their teaching day were missing in their math instruction.

Issue three. Students and teachers lack enthusiasm for math instruction. At one point early in the study, the teachers began discussing their personal histories as math students.

I think I mentioned to you guys before, I would always ask my advanced algebra teacher, well, why? What's behind that? You know it was constantly why, why, why? And his response would be, uh, we don't have time for that. Just memorize it. And I was horrible at memorization, so that was like the death knell for me. You know, don't tell me to memorize anything. I'm not going to be successful at that. I need the connection, as a learner, with the world, with my life, that sense of the social piece, the historical, the theoretical (R. Braverman, personal communication, October 18, 2011).

Although all participants had experienced varying degrees of frustration or failure in learning math, they all shared a common connection to the dryness, repetitiveness, or lack of relevancy in their experiences as math students. They had touched on this topic before in conversation, but it seemed particularly impactful when they made the connection to their own experiences; it was at this point in the conversation that the participants made a collective commitment to look for ways to foster enthusiasm and strengthen engagement in their students' study of math. Their conversation got at the heart of what was missing in their math learning and in their math teaching – the ability to bring math to life.

Poetry as an Entry Point

Equation
Someone said
that working through difficult equations
was like walking
in a pure and beautiful landscape-
the numbers glowing
like works of art.
(Caroline Caddy, 2007)

Because I believe so strongly in the transformative power of poetry and the connection between the similar structures and patterns found in poetry and math, I infused poetry into every inquiry session. I first introduced the idea of incorporating poetry into math instruction with the group as a whole at an after-school session in September when I shared the book *Math Poetry: Linking Language and Math in a Fresh Way* (Franco, 2006). RB and LK had been part of the pilot study group the year before and had explored some thinking around this concept; they had both experimented with using some math rap videos with their students and reported that although the students seemed very engaged, they did not seem to be performing any better as mathematicians. Nonetheless, my research into the work of Tate (1995), Berry (2003), and Bol and Berry (2005), especially, indicated that this was worth further exploration.

I began every session of our work together by reading a math poem, hoping that it would not only set an aesthetically pleasing tone for our meeting, I was also hoping that the infusion of poetry would allow the participants to be open to the idea of linking our math work with an exploration of poetry as a form of culturally responsive pedagogy. As

we began the October 18th after-school session, I read “Numbers,” a poem by Mary Cornish (2000). We spent the better part of the hour discussing particular students as well as the general math struggles at the different grade levels. One common challenge for students was the concept of number sense, and the teachers indicated that this struggle manifested itself in different ways depending upon the grade level. As we tried to narrow the scope of our lesson study, it was agreed that this could be an interesting area of focus, since the more difficulty the students had making sense of numbers, the more drastic their struggle to make progress in math.

Toward the end of our meeting, our discussion of the challenges inherent in building number sense evolved into the struggle that students at the lower grade levels were having with the concept of zero. I had brought several math poems with me to share with the teachers; I opened the book *Number Talk* (Pappas, 1993) and read aloud the poem “Zero.” It is a simple poem, but reading it caused the energy in the room to change.

Zero

I am zero.
Some say I’m nothing.
I know to the contrary.

invaluable.

line.

The positive numbers are to my right.

left.

I’m neither negative

I’m zero.

Centuries before I appeared

burdensome.

repetitious

I am zero.
I have no value.

I’m essential.

I’m the origin on the number

The negative numbers to my

nor positive.

I’m zero.

number writing was

confusing

<p>I was discovered</p> <p>Now with zero there is no mix-up,</p> <p>Without zero</p> <p>place-value system.</p> <p>I am zero. Add zero to any number the result is unchanged. Divide a number by zero There is no answer. I am zero. I am nothing.</p>	<p>I made the difference in the place value system.</p> <p>101 looks different than 11.</p> <p>there would be no</p> <p>I am zero. Multiply a number by me zero always results. Beware when dividing by me. The result is undefined. I am zero. I am essential.</p>
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Because this was a poem for two voices, the teachers wanted to hear it read that way; two participants took my book and read it the way it was meant to be read, alternating voices. At that point, CL, the school principal, responded to the energy in the room and suggested we try incorporating poetry into the lesson. The response was immediate, unanimous agreement. The simple act of reading a poem about a mathematical concept brought about the kind of enthusiasm that the teachers were hoping to infuse into their lessons with their students; they left the session excited about the possibilities. Within an hour, RB emailed the group a math poem that she had found online.

LK brought this idea of constructing math poems for two voices to her third graders and she reported the process back to the inquiry group at our next session.

So what I did was I put that up on the overhead and my kids read it, I explained how you read it, so they read it back to me and we did that for a couple of days. And then after that I said we're going to take this concept of association, um, and let's try to do a poem with it. So we started and I just said let's look at our chart for what association is, you know, it's that grouping thing. And so the kids talked about it and they said things like you know it's organizing and reorganizing, so I took notes on the board, and then one of them said you know it's kind of like making friends, and then somebody said it's like breaking up.(laughter) So I wrote that stuff down... So we came up with this poem. And I really just took it almost in the order that they gave it, so this is the poem (L. Konnigsberg, personal communication, October 31, 2011).

RB volunteered to read it with her to our inquiry group; LK and RB performed the poems that LK's students had constructed as a group effort, "Association" and then "Multiplication" (see Appendix B). This led to a sharing of other ideas and resources that could generate this kind of excitement around math.

It is impossible to be a mathematician without being a poet in soul.
Sophia Kovalevskaya (1850-1891)

When the group met for the next after-school session two weeks later, it was immediately following an all day session presented by social justice advocate, Dora Dome. Attorney Dome, invited at the request of the school principal, had worked with the staff the day before school started in August 2011, and this second event was a follow-up workshop session designed to tackle tough issues related to race, privilege, and bias. The

staff at NRE is predominately White, but 83% of the student body are children of color. The issues raised in the workshop helped to illuminate the work around cultural relevancy that the study group was grappling with.

The timeliness of this work gave me an opportunity to push the conversation toward the need for adopting more culturally relevant instructional practices. Dome spent the last hour of her workshop explaining Critical Race Theory and quoting heavily from the work of Gloria Ladson-Billings. This allowed me to remind the participants that I had recently added a Ladson-Billings article to our Dropbox folder, and to encourage them to read it in light of what they had just heard. This also allowed me to make sure that we went back and revisited this thinking as we delved into the next phase of our work together, lesson planning.

Lesson Planning

As part of our inquiry study, the teachers and I followed a Lesson Study protocol (Lewis & Hurd, 2011) based on the Japanese model of continuous improvement. This model promotes a culture of teacher inquiry that honors a cycle of research, planning, observing, and reflecting to build an understanding of students' thinking (see Figure 4.1). The lesson study is designed to allow teachers time, space, and resources to explore a topic. I found these to be critical components for the success of teacher inquiry, and will explore these factors in depth later in chapter four.

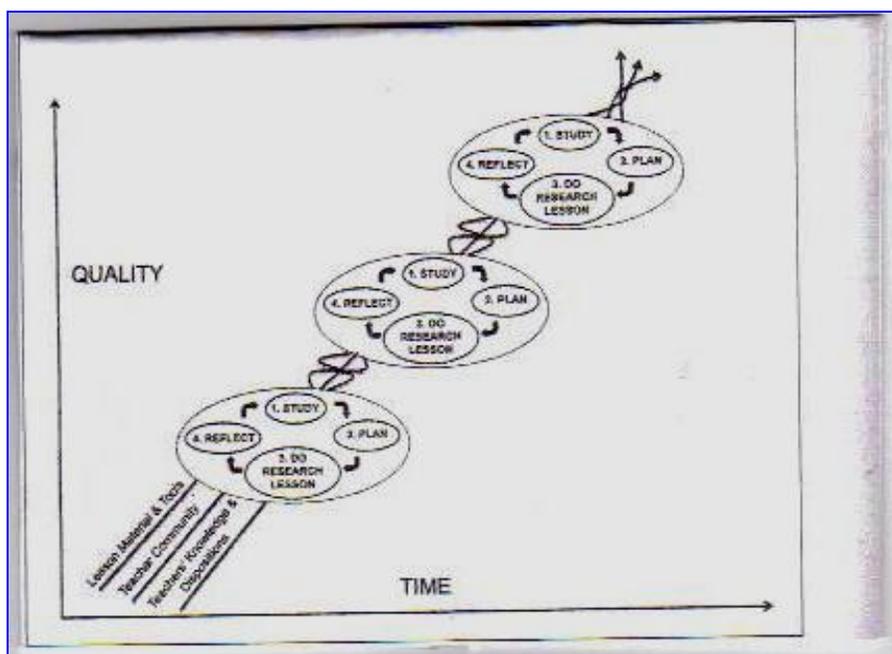


Figure 4.1. Lesson Study Cycle of Success.

On November 30, following five one-hour after school sessions dedicated to discussing current math practices, achievement gap statistics, research articles, math poetry, and struggling students, the inquiry group took a release day to plan a lesson together using the lesson study model. The day was chunked into four distinct sections.

Section 1: orienting our thinking. We began the day sharing anecdotes of our recent math experiences. I described a recent experience of observing a high school calculus class in a nearby school that shares the same demographic profile as NRE. I was interested in sharing the ways that the calculus teacher infused language arts and word work into his advanced math teaching. NS asked a question that got at the heart of our work and focused us on the social justice element that runs through all of our research into the achievement gap and students of color.

I'm just curious. Did you happen to take a look at the students in the room? What the demographics were (N. Strong, personal communication, November 30, 2011)?

Researcher: Yes, I did. Ah, there was one white boy in the room, there were a few girls, there were mostly Asian boys. Almost ninety percent of the class I would say, Asian boys.

Not even Indian (N. Strong, personal communication, November 30, 2011)?

Researcher: Oh, yes, Asian Indian.

Any African Americans (N. Strong, personal communication, November 30, 2011)?

Researcher: No.

N. Strong (whispered) Interesting (personal communication, November 30, 2011).

Researcher: Very interesting.

Tate (1995) argues that this phenomenon is due to the practice of tracking, relegating African American students into remedial math courses, a practice which has been shown to limit their educational opportunities, leaving them ill-prepared to use mathematics in order to negotiate the complexities of the democratic process. He suggests that traditional mathematics instruction acts as a gatekeeper, preventing African American students from fully participating in the world. This is further highlighted in the work of Stinson (2004) who has shown a strong correlation between the early

identification of struggling math students and their subsequent exclusion from higher level thinking experiences and opportunities to fully practice citizenship and realize economic success.

Researcher: I just wanted to go back for a second to the idea of culturally relevant pedagogy. I've been thinking a lot about the idea of poetry as a form of culturally relevant pedagogy, and what I mean by that is that it's a way into learning for some kids ...like you asked me, NS, were any of the students African American? No. And so we want to change that, right? We want to do something to make all kids have access to those kind of classes and that kind of thinking. So we want to be thinking about our lesson study is about number sense, but also, are we bringing in an element of making sure that all kids are being reached by the instruction?

I took this opportunity to revisit the five key components of Critical Race Theory that Dome had discussed in the October professional development day at NRE in her presentation, "Let's Talk About Race." Those components, as outlined by Dome, are:

1. Counter-storytelling: The story of the "other" that often goes untold but is necessary to understand in order to challenge racial stereotypes.
2. Whiteness as property: a brief history of the origins of US property rights, rooted in racial discrimination.
3. Permanence of racism: an examination of the hierarchical structures that govern political, economic, and educational systems. This is strongly tied to the racial achievement gap that allows us to predict achievement based on the color of students' skin.
4. Interest convergence: an examination of the theory that communities of color will succeed when doing so benefits the white majority.
5. Critique of liberalism: discussed liberalism as a flawed concept that ignores historical implications; embraces concepts that are insufficient to redress the deleterious and pervasive effects of racism on society.

This recap of Critical Race Theory and the resulting discussion led to a re-examination of the impact that day had on our attitudes and practices. The discussion elicited instances of recognizing personal biases, and also spoke to a heightened awareness in our daily lives. Teachers talked about the reactions of other teachers to that professional development day and the complexity of this work with our students and our colleagues. The conversation seemed to be less fluid than other conversations we had been having and I wanted to surface some of the unspoken challenges that seemed to be at play.

Researcher: I'm just thinking that the work we're setting out to do is a math lesson study, right? But I think one of the things we have going for us here is that we're bringing all these other underlying symptoms of educational inequality to our work. And we might not address it explicitly, but we're going to be thinking about it when we're designing lessons. And just the fact that we're having this conversation, it's an uncomfortable conversation, for sure, it doesn't feel good to talk about these things sometimes, you know, you don't know what to say and sometimes we don't say what we're really thinking because we don't want to offend, but we've got to talk, right?

I just noticed that every time, before we say the word black or white, there's just a millisecond of hesitation before we say the word (N. Strong, personal communication, November 30, 2011).

I find that's true here at school, but when I'm talking with my friends or family, I don't hesitate (R. Braverman, personal communication, November 30, 2011).

There was a long pause, and then the conversation jumped back to a discussion of what makes a good teacher. I did not realize it at the time, but because we were at that point seemingly unable to stay with a challenging topic, and unsure of how to redirect the conversation, I chose a familiar strategy, asking, "How are we going to look at this (math) in a different way so that all our kids feel safe and connected? Can I just share this book with you?" I held up *This Plus That: Life's Little Equations* (Rosenthal, 2011). I read the book aloud, then asked the teachers to take a few minutes and write down what they were thinking at this point in the morning. I used my experience as a staff developer to allow participants to struggle with the discomfort individually rather than jeopardize the progress we had been making as a group toward teaching math in a culturally responsive manner.

Section 2: learning from a lesson study model. In order to have a shared experience of the process of lesson study, I elected to show the teachers the DVD that accompanies the text, *Lesson Study, Step by Step: How Teacher Learning Communities Improve Instruction* (Lewis & Hurd, 2011). The DVD is approximately 22 minutes in length and is divided into the following sections: planning and study, first teaching, first post-lesson discussion, second teaching, second post-lesson discussion, and final reflection. In the video, a group of teachers who are immersed in the lesson study process plan a lesson that they believe will reveal a depth of understanding in their elementary

math students. Upon debriefing the lesson, they come to understand that the lesson did nothing of the kind; in fact it had the opposite effect, actually limiting the thinking of the students.

The NRE teachers read over their notes before discussing as a group. The idea that resonated with all was best summed up by N. Strong when she said, “It just shows that in all this math, we’re only just as effective as our level of understanding” (personal communication, November 30, 2011). I point that out here, because this statement also served as a constant reminder to me as I continued to conduct the case study research with this group of teachers. In all that we do, we are only as effective as our level of understanding.

When teachers understand the math at a deeper level, they can bring a different approach to their teaching to help facilitate student understanding. Without a firm foundation in the factors that contribute to academic achievement of our students, we are hard-pressed to make decisions that effectively combat inequity and allow all students the opportunity to have a rich experience with mathematics, to develop a math identity. Developing lessons that take this stance into account honors the work of Gutstein (2006) and Tutak et al. (2010) who have called for major pedagogical shifts that counter the traditional teaching of mathematics that fails to take issues of equity into account.

The historically traditional perspective of mathematics instruction limits the opportunities for all students to thrive as mathematicians. Although we expressed this idea many times in our lesson study together, and even though we discussed it in light of our shared video-watching experience, as a group we found we kept overestimating our

own depth of understanding. Throughout the lesson study process we continued to make mistakes, which will be detailed later in the chapter. That, though, is the beauty of the lesson study process, providing ample opportunities to examine and re-examine our work through the lens of equity.

Section 3: building understanding through shared resources. In addition to the Dropbox folder that contained research articles, as a group we had collected numerous other resources. I directed the teachers to read with the idea of designing a culturally responsive lesson focused on number sense. Teachers had their laptops with them so that they could explore the Dropbox articles or do Internet research; I set up an additional laptop and headphones for reviewing the DVD, although no one opted for that in our limited independent study time. The room was absolutely silent for the entire hour as teachers read and took notes individually.

This was a critical piece of the process given that teachers rarely have time in their day devoted to quiet reading and reflection. Much of what we gleaned from just one hour of independent study contributed to deepening thinking and strengthening the inquiry process. The conversation that framed the design of the subsequent lesson was based on research and resources rather than intuition and conjecture.

Section 4: planning the lesson. Planning the lesson as a team took more than four hours; it was not lost on us that we were spending nearly an entire day as a group of six teachers to design one 45-minute lesson for 25 first graders. According to Lewis and Hurd (2011), “lesson study builds educators’ knowledge, motivation, habits of learning and professional learning community” (p. 16). The power of this work is in the process,

not the lesson that is the resulting product. This understanding is further substantiated in the conditions for change set forth by Steinberg et al. (2004), which specifies membership in a discourse community, employment of explicit processes that support honest conversation and reflection, and ownership of the resulting process of change.

The teachers played very specific roles in the lesson planning which I will discuss later in this chapter under the section The Collaborative Process: Establishing a Community of Practice. We spent nearly an hour sharing our ideas about what should be included in a number sense lesson. One idea that was explored in depth was the importance of including poetry in whatever lesson we designed. Poetry was mentioned by every participant and covered a range of suggestions for supporting students and the concepts being taught including:

- as a warm-up activity to set a positive tone
- as a vehicle for valuing divergent thinking
- as a way of adding rhythm or movement into counting
- as a tool for demonstrating understanding of a mathematical concept
- as practice for finding joy and passion
- as an example of exploring patterns

All the talk about poetry allowed the teachers in the room to entertain a variety of lesson possibilities that were focused on math and language arts working in concert. This logical intertwining of words and numbers to deepen understanding was recommended by the National Council of Teachers of Mathematics (1996) and has been further explored by researchers such as Moje (2008, as cited in Friedland, McMillen, & del Prado, 2011), who suggest that content area teachers need to view “literacy practice as an integral aspect of subject area learning, rather than as a set of strategies for engaging with

text” (p. 62). This philosophy is one shared by many educators and promoted in the proposed National Content Standards for Math.

KHJ, who is a quiet, thoughtful participant, was able to synthesize the thinking that occurred over the course of the morning, and propose a lesson focus that the entire team grew excited about planning. It did not include a poetry piece, per se, but the talk around the importance of poetry and the ensuing conversation resulted in this exchange:

So a lot of it has to do with not having words for what they’re seeing. So there’s like this whole math language they’re responsible for and I think that’s totally overwhelming as you get up into the upper grades. You get to geometry and there’s like 150 math terms that they don’t use, definitely not on a daily basis, so I think that’s because they don’t have words to articulate (R. Braverman, personal communication, November 30, 2011).

Researcher: So how would that look?

Well, if we were going to do a whole hierarchy of vocabulary, what would be the first word we’d want to teach, and could that help get us to our lesson (L. Konnigsberg, personal communication, November 30, 2011)?

I just had an idea, and this might be just kindergarten, but when you said vocabulary, it made me think, like the word that popped into my head is equals, and the balance, you know how the equal sign is in the middle of the scale, and then I started thinking about that (the book, *This Plus That*, Rosenthal, 2011) and how anything on this side, whether it’s a string of things, can equal one thing, and that can go into understanding number

value too. Anyway, that was just my word (K. H. Joyce, personal communication, November 30, 2011).

That's huge (L. Konnigsberg, personal communication, November 30, 2011).

That's a huge concept (R. Braverman, personal communication, November 30, 2011).

Researcher: KHJ, do you have more thinking around that?

I don't know 'cause it just popped in my head. I think that you know, an ending goal being how do students show their understanding of the word equals? That could have infinite possibilities, and being able to explain why and how they got to that place, and that understanding of that word could be really interesting (K. H. Joyce, personal communication, November 30, 2011).

It took the rest of the afternoon to construct the lesson (see Appendix C). NS volunteered to teach it first and because IR also teaches first grade, she agreed to teach the second, revised lesson. The lesson title we settled on was Understanding Equal, and our stated goal was "students will demonstrate an understanding of the math term 'equal,' explain their thinking, and critique the reasoning of others." The lesson addresses the following first grade California State Standards: 1.2, Understand the meaning of the symbols $+$ $-$ $=$, and 2.1, Explain the reasoning used and justify the procedures selected (California Department of Education, 2011).

Teaching the Lesson

One week after the lesson planning session, the teachers were given another full-release day, again funded by the Northern California Math Coalition. The day was structured for an initial pre-brief session to review the lesson and give participants a brief profile of the students being observed, a one-hour block for teaching the lesson, an hour to debrief and reflect, and then a full afternoon to revise the lesson based on our observation. This revised lesson was to be delivered in IR's first grade classroom the following week.

Class Profile of First Graders

NS explained to the teachers participating in the inquiry study group that there are 25 students in the class; one is absent on the day of the observation. Five students are identified as English Language (EL) Learners. Of those five, one student is completely fluent in English despite her EL classification. Three boys are positioned at the front of the classroom due to behavioral issues. NS indicated that she had some very high readers including SS (super bright but he has difficulty with self-control) and DT (who is an "out of the box guy"); also, there are two students that she refers to as "my RTI (Response to Intervention) kids."

Preparing to Teach

N. Strong, who has to this point been so excited about teaching this lesson, reveals some trepidation right before the lesson begins.

And we talked about, expectations are still up here, but our group is getting bigger and bigger, and bigger (researcher's note: last year district

kindergarten – third grade classes were staffed at 20:1, in 2011-2012 primary classes were increased to 26:1 staffing), so to be able to do something like this, and look at math in a different way. I'm all for that, but I'm thinking too, how's it going to fit into my lesson plans, my expectations for the end of the year, this report card that I have (personal communication, November 30, 2011)?

The issue raised here by NS, just as she was about to deliver a lesson that was weeks in development, falls right in line with what research says about change. Teachers who exhibit initial change in attitudes and practices based on their growing understanding and beliefs about children's problem solving do not necessarily sustain that change or continue in the change process. Steinberg et al. (2004) have illustrated the importance of finding support systems to help teachers sustain and continue applying their new knowledge about teaching and learning; even when change is approached thoughtfully and methodically, it is challenging to implement. The pressure from outside sources and past practices can be monumental.

NS's lesson went well and she was obviously pleased with her teaching and with the students' performance. In the opening minutes of the debriefing session, she recapped the highlights of the lesson, which included the genuine delight exhibited by the children as they listened to the book, their ability to write meaningful equations, and the fact that all students were able to either agree or disagree with a statement as a first step in the critiquing process.

Reviewing Student Work

I suggested that we spend some time reviewing the student work samples NS collected before we finished debriefing the lesson. We identified some of the students NS had told us about in the pre-brief session (EL students, behavior issue students, high readers, etc.) and examined their work. There was so much excitement among the teachers for the variety of equations that students wrote, but we failed to do any in-depth analysis.

In the lesson, the students each wrote one equation; students moved from desk to desk and decided whether they agreed or disagreed with the written equation. When I read the student example in Figure 4.2 out loud, there was a chorus of “Oh, how sweet!” but we did not explore what that told us about the thinking the student exhibited, and I did not push the participants to do so.

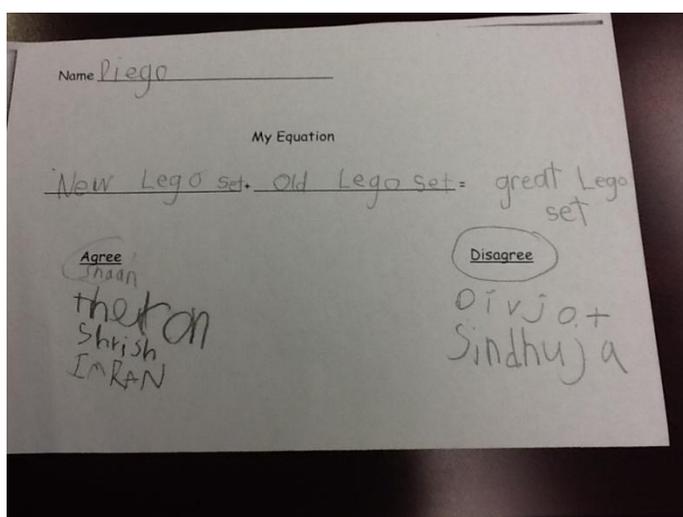


Figure 4.2. First Grade Example of Equation Writing.

Planning Revised Lesson

It was interesting that when looking through the lens of revision, teachers were able to use the morning's lesson as a jumping off point for crafting a much more effective lesson that would get at deeper levels of thinking, explanation, and critique. This phenomenon is similar to what happens in writing – in order to craft a substantial piece that says what the writer intended, the writer has to first get a draft on the page. The inquiry group was extremely pleased with our “first draft” lesson when we constructed it and when NS delivered it; it was only when we began to re-examine the lesson and refer back to our stated goals, that its weaknesses were revealed.

Changes that we made to the revised lesson included:

- choosing purposeful places to pause in the reading to elicit predictions and responses in order to scaffold children's learning
- giving students opportunities to partner talk
- methodically repeating of the word equation throughout the lesson (new concepts, new vocabulary require repeated usage)
- adding an equation that contains a minus sign (i.e., sleeping late minus the alarm clock equals weekend)
- redesigning the paper students do their work on to include a section labeled write your equation here (no lines for them to write on), a section for explaining thinking, and a space for an illustration
- pre-teaching accountable talk strategies and posting a chart
- teacher demonstration of critique with opportunity to practice on another teacher example

The teachers were very excited about the breadth of this lesson and the opportunities it allowed for students to deepen their thinking. Early in the process we had decided as a team not to move to numbers right away, but to leave the lesson as one that first explored the idea of equal and equation, taught into substantiating an equation with reasons, and being able to critique the reasoning of others. Focusing on the language of

equations first was an idea that we wanted to explore based on the research we had done. A chapter from a book I recommended early in the process was mentioned often by the participants. Minton (2007) illustrates that taking what they know about literacy instruction and applying it to mathematics instruction strengthens teacher's math instruction and deepens student's math comprehension.

Nevertheless, the participants were wary that other teachers would see this as a weak or ineffective lesson because of its focus on language instead of numbers. We saw it as a critical first step in building understanding, the first in a series of lessons that were intended to explore the idea of equal. The talk circled back around to the importance of being clear with the students that thinking like this means you are a mathematician. Writing equations, defending your reasoning, and being able to critique others' reasoning is powerful math thinking.

The revised math lesson (see Appendix D) included all the changes above as well as several places within the lesson to formatively assess students.

Learning from Revision

The principal, who had not seen the initial lesson, was able to observe the revised lesson delivered by IR, and she also joined the debrief session afterwards. She initiated a conversation that focused on the engagement of the students throughout the entire lesson. She commented on the level of differentiation that allowed all students to be successful, and she specifically mentioned the teacher modeling, the visual prompts, the oral language scaffolds, and the purposeful use of student examples.

IR pointed out that the lesson would have been stronger if it took place over two days. We discussed some of the interesting mathematical misconceptions that were revealed in this one lesson, for example, $a + b = a$ was a misconception that was evident in student equations like “playing + riding my bike = playing.” Examining this question led the participants to explore the idea of introducing more scaffolded instruction to support student thinking, and to consider that schools with students who are more challenged than the students here at NRE may need even more scaffolds. There was a general agreement that because all our students were able to write equations and explain their thinking (even if it was not correct) this lesson was accessible to all.

In the discussion of the lesson, RB referred back to an idea that NS had offered in our early work together about the role of teacher understanding in instruction. Her observation led to the following exchange, which in turn led to a further revision in the lesson design.

So I was looking back at our goal. Students will demonstrate an understanding of the mathematical term equal and explain their thinking and critique the reasoning of others. I don't think, did we ever determine, did we come up, for ourselves, an understanding of equal? Did we decide together what our definition of equal is (R. Braverman, personal communication, December 15, 2011)?

We talked about it a lot, like fairness or sameness (K. H. Joyce, personal communication, December 15, 2011).

We talked about what the grade levels' concept development is (I. Reedy, personal communication, December 15, 2011).

Researcher: But not what our understanding is.

After a lengthy discussion, we changed the goal of the lesson from “students will demonstrate an understanding of the math term ‘equal,’ explain their thinking, and critique the reasoning of others,” to “students will explore the concept of equal, explain their thinking, and critique the reasoning of others.” This took place after weeks of considering culturally relevant pedagogy, the power of poetry, number sense, student engagement, student achievement, and lesson study. As a researcher, this crystallized for me the complexity of this work. We had designed what we thought to be the most meaningful, considerate, equitable lesson, only to discover that it did not accomplish what we had intended. What it did do, however, was make an indelible imprint on our attitudes and practices, participants, and researcher alike. Steinberg et al. (2004) found a strikingly similar pattern in their research, characterized as an integration of inquiry and instruction, in which both teacher and students learned.

We could apply a statement that RB made about the students to our inquiry study team as well.

Understanding is forming mental connections. To understand means to grasp the relationships among mathematical facts, procedures, concepts, and principles by building upon prior knowledge. So I think this is fantastic, what we came up with, as a building block to being able to do that. What I see in my students is that when they go to explain their

mathematical thinking they often leave out a piece. So they explain it to a point, and then leave out some important, key aspects. And they did that in these life equations as well, so then what does that tell us about them developmentally, what's going on, you know, with their thinking, and how we need to explicitly teach (R. Braverman, personal communication, December 15, 2011)?

Teacher Empowerment

A theme that ran throughout the research was the growing empowerment of the participants. This was evidenced in the statements that they made in the inquiry study group settings, in their continuum of practice comments, and in their individual contributions to the design, planning, and implementation of the lesson study. N. Strong, who spoke tentatively about math literacy in our initial meetings, "It's not natural to me. I just think of math as math time, and language as language time," (personal communication, October 31, 2011) explained that she learned math in isolation and had difficulty thinking differently; nevertheless, she volunteered to teach the first collaboratively written lesson for her inquiry group peers. Over the course of an hour, she expressed the following ideas, shifting her perspective as the conversation progressed.

Well, I think we're approaching this math as not your standard, standardized test, black and white, this is the right answer, and that's the only way to get to it, but that we're looking at it through the lens of language, through the lens of experience, and culture... It's a little tricky because it's math. If it were language, it might be easier to work with.

Math, it's just abstract, it's numbers, it's not comfort, you know, for a lot of people, but I think the more articles we read ... I mean I don't mind teaching the lesson, I just want preparation, you know? Especially with first graders... Well, at any rate I think it's a learning experience, anyway (N. Strong, personal communication, October 31, 2011).

Teaching the lesson was a confidence boost for NS. She entered the debrief session noticeably excited. The success of that lesson, the thoughtful, positive critiques of the other participants, along with NS's reflection and contribution to the lesson revision, empowered her to volunteer to teach the revised lesson to a first grade class in an urban school as part of the Northern California Math Coalition's Lesson Study Open House to be observed by several outside researchers. "I want to see what's out there. We know what our kids can do... If you go to a demographic ... that is different than that, how does your teaching relate, how does that effect your teaching?" (N. Strong, personal communication, December 8, 2011).

In differing ways, each participant showed evidence of being empowered through the process. IR remained a quiet voice throughout the study, yet she contributed to the group by sharing resources, designing a template to allow students to demonstrate their thinking in more authentic ways, and modeling the revised lesson for the principal, a mentor teacher, and the participants. LK shared student-constructed poetry with the group, typed up all the lessons we wrote, and introduced interesting concepts that pushed participants' thinking. RB continued to explore inquiry by introducing the math equation concept into other subject areas, and by introducing practices that she had honed in

teaching language arts into her math work with students. She also continued to pose questions and point out strategies that might better help students construct strong mathematical thinking. KHJ demonstrated her increasing empowerment by first taking on the role of scribe, synthesizing the groups' thinking in writing, and listening intently for moments of leverage, places in the discussion where she was able to crystallize the various points of view and introduce new ideas that became the heart of our lesson study. It was KHJ's quiet leadership that allowed the group to design a foundational math lesson focused on building viable arguments and critiques to support an understanding of equation, a skill we deemed necessary for all students to have access to successful mathematics experiences. The significance of collaborative inquiry is related to the process by which group members co-construct knowledge (Cooper, 2006); the resulting empowerment of the participants was due to the collaborative process of the group.

The Collaborative Process: Establishing a Community of Practice

Wenger (2006) defines a community of practice as a group of people “who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (p. 1). Wegner expresses the crucial characteristics of these communities in terms of domain, community, and practice. These themes were evident throughout the inquiry study and I will explore these three concepts in depth through the following expanded definitions:

1. Time, Space, and Resources: Three key ingredients in successful collaboration (domain).
2. Group Dynamics and the Prism Effect of Talk: growing ideas together (community).

3. Transformative Synergy: Words + Patterns + Mathematics + Culturally Relevant Pedagogy + Teacher Inquiry = Changed Attitudes and Practices (practice).

Time, Space, and Resources

One Point in Time
*As I stand on a plane,
 I see one perspective.
 A slight rotation,
 and I can see another.
 My possibilities are infinite
 because I am one point in time.*
 (Lisa Harden, 10th grade student)

The participants and I met for substantial amounts of time in sessions lasting from one to seven hours over a four-month period. These extended meeting times allowed us to establish roles, build trust, examine beliefs, consider alternative teaching strategies, explore resources, and engage in deep and often difficult discussions. During these sessions we read poetry, investigated research articles in peer-reviewed journals, shared picture books, studied student work, reflected on the essential elements on a continuum of teaching practice, discussed specific students, took notes, designed and revised lessons, observed in classrooms, etc.

Because we received support from the principal through a grant from the Northern California Math Coalition, we developed a strong community of practice. Not only did she allow for the teachers to be released from their classroom responsibilities on several occasions so that we could delve deeply into our inquiry work, she also provided a dedicated conference room on the school campus to house the group. This allowed us quick and continuous access to classroom materials and to students. We were also provided a shelf in the library to store our growing collection of resources, and internet

access in the conference room gave us ready access to the Dropbox service where additional articles, transcripts, photographs, and videos were stored.

At the beginning of the inquiry study in August, I introduced the idea of framing our study with research. I introduced the participants to a few articles by researchers who had exerted a strong influence on my thinking, particularly Gloria Ladson-Billings and Geneva Gay. I also introduced a chapter from the text, *What If Your ABC's Were Your 123's* (Minton, 2007). Later, I added newspaper articles, charts, notes from lectures I'd attended, and transcripts of our sessions together. Of all the resources that I introduced the participants to, there were two that played a major role in the evolution of the inquiry study, neither of which was overly academic. The Minton (2007) chapter is referred to dozens of times in the transcripts, and seems to be a foundational component of this study. The text from which we drew our inspiration for the lesson study, and which continues to inform much of our thinking, is the Rosenthal (2011) picture book about life's little equations. This is an interesting finding that illustrates the importance of relying on culturally relevant entry points for teaching complex ideas. These texts that spoke to the teacher's hearts, closely matched their interest levels, and contributed to their enthusiasm and engagement, empowered the participants to revise their practices and to provide their students with exciting new ways to think about math.

As the researcher, having modeled the process of relying on academic research, as well as a variety of outside resources to guide our inquiry, I was excited when the teachers began to embrace this process themselves. Participants added articles to the on-line resource repository and collected books and student work samples related to our

study, and these additions contributed to the collegiality of the group. The more the participants met and shared resources, the richer and more authentic the inquiry became, a phenomenon I attribute to the time and space provided for study and the growing empowerment of the participants. This allowed us to move well beyond simple, surface exploration; the more the participants read and discussed, the more curious they grew around the role that culture and tradition play in instruction and learning expectations, and the more closely they examined their own attitudes and practices.

Group Dynamics and the Prism Effect of Talk

In order for a group to function dynamically, there need to be differing perspectives and stances at work. The participants in the study group were united by their initial interest in taking part in a math study, their common work environment, their concern for their students, and their frustration with traditional instruction and its inability to address the needs of all students. They were, however, a diverse group, representing different cultures and educational backgrounds, different teaching styles, and different personalities and communication skills. These differences contributed to the various roles they assumed in discussion, and I have likened their conversation to a prism effect. Through a prism, images are reflected and refracted, changing angles and points of view. When analyzing the field notes and transcripts of this study, this metaphor emerged and I think it is a fitting one. The participants' views of themselves and each other shifted and grew as they moved through the study.

In the first few sessions, RB and LK dominated the conversation. This was due, in part, I believe, to the fact that they had been part of the previous year's pilot study, and

had a familiarity with me and with my facilitation style. They felt comfortable sharing their opinions and ideas immediately, and the conversations initially were heavily controlled by the two of them. NS contributed more and more to the conversation as time passed, and by the time she volunteered to teach the first lesson she had an established voice in the conversation.

L. Konnigsberg continued to try out sometimes radically different lines of thinking throughout the entire study. For example, in an October after school meeting, when we were reviewing the criteria sheet from NCMC regarding constructing viable arguments and critiquing the reasoning of others, she suggested, “I’m wondering if, just to make it even more complicated (laughter), like this whole idea of like using the digital camera for whatever we’re doing. Ok, find an example of the truth of that in your life and tell us how that is. Set up a picture to tell that story” (personal communication, October 31, 2011). R. Braverman (personal communication, October 31, 2011) responded, “Do what?” followed by, “I missed...” after which she trailed off in confusion. LK acted as a verbal processor in conversation, thinking out loud, and offering many ideas that although they were not often realized, still served to open up our thinking to a wealth of possibility. She helped us to broaden our perspective by allowing us to entertain abstract, non-linear lines of thinking.

RB’s role was that of summarizer, questioner, and articulator. Often, following a lengthy exchange, RB would encapsulate the conversation that had just taken place into one or two salient points. She helped to keep the conversation focused. Here is an example of RB’s skill at summarizing, questioning, and articulating all at once.

Well, I think what's successful for us as a lesson is that it clearly was bringing out the conversational piece that was one of our main goals, being able to support your thinking. A big question that came up for me, I found it so interesting... I see in their thinking the same issues that they have when they go to explain their reasoning with a purely mathematical equation, with numbers, which is they often only refer to certain parts of the equation and are completely missing rationale for other parts. So many of these, both in the critiques and in the explanations of thinking... only take one piece of (the equation) and explain that (R. Braverman, personal communication, October 31, 2011).

Following this, the conversation moved into strategizing how to structure a lesson so that students would be able to address every part of an equation. The participants were able to shift their thinking into action, keeping in mind the mathematics and the relevancy of the lesson so that students would be able to demonstrate understanding of the concept being taught through language. It was RB who continued to remind the group that although the students were competent memorizers, they were not strong in mathematical understanding, and that in order for us to provide equitable instruction, we needed to stay focused on our purpose.

IR was a quiet voice throughout much of the study, preferring a role as listener. At one of the first sessions she shared some poetry picture books that she wanted to use with her class, but other than that she did not say much. She expressed feeling uncomfortable when discussing issues of race and ethnicity, perhaps due to

manifestations of her own culture. She did not immediately volunteer to teach the revised lesson in her first grade classroom, in fact it seemed as though she agreed only when it was pointed out that since the other first grade teacher (NS) was presenting the first lesson, IR should teach the revision lesson in order for the group to compare the student response across the same grade level. After NS taught the first lesson, IR did become involved in the debriefing and in designing the revision lesson, adding to the discussion when it directly impacted her instruction. It was IR who designed the student template, and explained the importance of modeling a variety of equations. Her listening stance throughout the process allowed her to contribute critical steps in making the lesson strong, relevant, and culturally proficient.

NS evolved into the risk-taker of the group. As she was entering the classroom to teach the first lesson designed by the participants, she was wondering aloud about the process, and expressing doubt about its relevancy. Because it went well, her stance in the subsequent conversations grew more confident, while at the same time more willing to risk the unknown. Her desire to research what would happen in different classrooms with different students propelled her to volunteer to teach a lesson for a group of total strangers in a classroom not her own. The more we met, the more curious she became about students' learning, the influence of culture, and the role of language in mathematics instruction.

Of all the participants, KHJ contributed the least verbally. During an early session she grabbed a marker and took notes on the whiteboard in the conference room, capturing the groups' thinking, and categorizing our comments. This is a necessary role in a group

such as this inquiry study in order for participants to monitor their thinking, check for understanding, and discover patterns of ideas. It was a role well suited to KHJ as she captured the conversation as it quickly wove from idea to idea and back again. I found it most telling that it was KHJ's comments that raised issues that the group had overlooked, such as some of the examples being too gender-specific, the design of the first template limiting the ability of the students to demonstrate understanding, and the power of teaching the concept of equal through a language experience. It was KHJ's patience, waiting to enter the conversation at critical junctures, and her attentive listening that served as leverage points in the discussion.

Transformative Synergy: Words + Patterns + Mathematics + Culturally Relevant Pedagogy + Teacher Inquiry = Changed Attitudes and Practices

Each of the participants played different roles that worked synergistically to impact the attitudes and practices of the group as a whole. Cochran-Smith (2004) emphasizes that this synergy is critical when dealing with issues of race, culture, and language diversity in schools today; it is the process of asking questions, entertaining disparate points of view, gathering multiple sources of information and experience, and balancing individual strengths and needs that leads to empowerment and change.

This process was at play throughout the study in other aspects as well. Each of the participants moved along the continuum of teaching practice in subtle and not so subtle ways. They presented their findings to the staff at the school in early March, and shared the following specific changes:

Exploration: Students see math as more than numbers, and show an increased interest in experimenting with the concept of equation, transferring into other content areas.

- Inclusion of equations in narrative writing (4th grade example: “Wait a minute. Talking dog + non-hallucination = real talking dog!”)
- Use of equation in history (1st grade example: Mean Laws + Martin’s help – Stores don’t have money = Laws are changed!)
- Equation as a tool for explaining scientific phenomenon [4th grade example: (Dinosaur + Earth) – humans = Prehistoric times]

Math Vocabulary: Increased accurate use of the terms equation and critique by students.

Engagement: Poetry and story build student excitement and increase engagement in math.

Application: Smooth transition into kindergarten addition unit.

Teacher Attitudes: Teachers develop a clearer understanding of students’ ability to reason, explain and critique.

The participants explicitly noted changes in their teaching practice including an increased reliance on knowledge of students’ cultural backgrounds and individual social, emotional, and physical needs to plan instruction, increased infusion of differentiated instructional practices that address culturally responsive pedagogy and diverse learning styles of students, and a higher level of collaboration with colleagues. All the participants were particularly effusive about the power of collaboration and the impact that this had on their learning, on their students’ learning, and on the learning of their school community. Furthermore, they expressed an interest in engaging with the broader professional community to share their practices and to continue the research process.

When reflecting on their classroom practice, two of the teachers reported that as a result of this study they saw themselves as innovators, using assessment data to continually refine their lessons, making adjustments to coincide with the learning needs of all their students. Additionally, RB reported placing a stronger emphasis on

developing math problems that would allow her to more clearly assess the students' thinking, devoting more classroom time exploring students' interests, and teaching explicit talk strategies.

Teachers reported that when students were told, "Now you're going to get a chance to write your own equations", there was a resounding "Yes!" from even the most struggling math students. All students in the study were able to write at least one equation, explain their thinking, and critique the reasoning of other classmates. L. Konnigsberg (personal communication, January 31, 2012) said, "And the powerful part is, they're owning it." By it, she means the students have taken ownership of their learning. The math has become relevant to their lives, something that the participants said was missing for many of their students when we began the inquiry study.

Ernst (2002) (as cited in Stinson, 2004) identifies three domains of mathematics empowerment, which are further supported by the findings of my study; mathematical empowerment through language, social empowerment through critique, and epistemological empowerment through a growing confidence in one's own ability to learn. The participants in this study reported a transformation in their attitudes and instructional practices through their inquiry into culturally relevant pedagogy and math instruction, and expressed a newfound commitment as advocates for change as well. Transformation can occur when educators embrace their roles as agents of change, committed to assuring that all students are provided opportunities to achieve and succeed academically (Friedland et al., 2011). Through interpretation, data analysis, and deep reflection, I found that the participants in this study, myself included, came away from

the inquiry process changed for the better. Our work together impacted our attitudes and our teaching practices.

When you know better you do better.
Maya Angelou (1928-)

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

High expectations and rigorous instruction are critically important to student academic success. It seems though, that in the quest to make sure that school curriculum is challengingly rigorous, those who educate, design curriculum, and make policy have somehow lost sight of relevance. The long-held practice of compartmentalizing the school day into various subjects that are taught separately, as though they had no connection to each other, has in many ways led to a stratification of learning and ultimately to a marginalization of students – those who can, and those who never will get the chance.

The genesis of my research began years ago in continuation high school classrooms where I saw students who had been disengaged from the learning process, marginalized by their schooling, and caught up in a cycle of failure. As I followed the winding path from high school backwards to the tracked classrooms of elementary schools where students are often separated by ability, potential, and standardized test scores, my focus changed. The stratification of learning, more often than not, falls along racial lines. Although I had spent my entire career as a language arts teacher and mentor, what I saw happening in elementary math education gave me a new direction as a researcher.

Talking to a colleague who teaches the highest level of mathematics in a high-achieving suburban school district, we discussed the path that students must take to enroll

in those courses. The path begins quite early; I realized that struggling third grade math students had a slim chance of ever following the path to calculus, although the likelihood of them following the path to low-level secondary math courses or to continuation high school classrooms was a somewhat predictable fate. Some of these students might become statistics in the educational landscape, failing to meet even the minimum requirement of high school graduation, relegating them to a lifetime of unrealized dreams. Tutak et al. (2011) suggest that the goal of mathematics education is to empower students in order for them to participate fully in socially just, democratic communities. Knowing that mathematics is seen as the gateway to higher education, and subsequently to position and power within the dominant culture, I adopted a stance of unlocking the mathematics gate through poetry.

A mathematician who is not also something of a poet will never be a complete mathematician.

Karl Weierstrass (1815-1897)

The research on poetry as a game-changer, as an identity-shaper, and as a voice-builder is rich and extensive. That is where my research began, and where I thought my study would end up. But like all paths where the end is out of sight, there were many twists and turns and unexpected discoveries along the way. I thought the introduction of poetry as a means of delivering culturally relevant math instruction would be a linear process. At the time I was beginning this research, it seemed a simple and obvious equation: Poetry plus math equals empowerment. But nothing worth pursuing is ever quite as simple and straightforward as it might seem.

As the inquiry process evolved, poetry did serve the purpose of introducing a paradigm shift in the participants' thinking. Number sense was the overarching idea that the participants were initially interested in examining, but as we worked together, the lesson design became less about numbers, and more about developing understanding and articulating thinking. I do believe this shift was due as much to the time and space allotted for our study as to the process that allowed the participants to make such meaningful growth as scholars and practitioners.

In many classrooms, students are not permitted to construct a personal understanding of the mathematics that is presented (D'Ambrosio, 2001), but that is just what happened when the participants introduced the idea of writing life equations into their mathematics instruction. For example, the variety of equations that surfaced in a fourth grade classroom following the lesson study process highlights the personal connections students were making.

- $TV + Patriots + Football Channel = Awesome$
- $Free\ time + Computer + Weekend - Mom = Video\ Games$
- $Rythem [sic] + Sound + mucseles [sic] + mind + tap\ shoes - music = Acapella\ (tap\ dancing\ without\ music.\ You\ are\ the\ music.)$
- $Books + low\ voices + quiet\ sounds + comfortable\ area = entering\ another\ world$

When the participants and I presented the lesson study results to the staff at NRE, we shared a number of cross-curricular student examples from kindergarten through twelfth grade, read the Rosenthal (2011) picture book, and asked the staff to construct

their own equations. They did just what the students did; focusing on their own lives, again pointing out the importance of relevance in learning.

For example:

- high school senior + college applications = empty nest
- parenting + (responsibility + dog) = my life
bills

The Role of Relevance

If mathematics is indeed the gateway to higher education and a wide world of possibilities for the future, how do we go about making the learning relevant?

Furthermore, how do we make sure that the learning is culturally relevant and accessible to all students? Looking at traditional math instruction, the gate still seems locked. Not only does the world of math seem to be less than inspiring for a number of students, it has become clearly evident that it feels the same for their elementary school teachers, many of whom likely had their own comprehension struggles or lack of inspiration when it came to the math they were teaching. Lack of inspiration plus questionable comprehension equals bored students.

Plenty of students know how to play the school game; they can survive a lackluster educational experience, and can find ways to thrive. But for students who struggle, this takes on crisis proportions. Society cannot afford to let these students continue to lag behind the rest when research confirms that educational achievement is the foundation upon which successful societies are built and maintained. Our study of poetry as a culturally relevant pedagogical tool helped the teachers to explore their own teaching practices, their attitudes towards math instruction, and to work hard to build

lessons to engage and excite, and most importantly, to build deep, critical thinking skills for their students.

Berry (2003) has written extensively on the role of culturally relevant pedagogy in the lives of student mathematicians. In an article connecting the National Council of Teachers of Mathematics standards with the relational learning styles prevalent in the African American population, he explores the advantage that analytical thinkers have when taught traditional math, and suggests that a more socially just method of instruction would make clear the connections between ideas and experiences. Focusing on relational experiences, which present material contextually, gives students opportunities to develop deeper understandings and build a stronger connection to mathematics. This line of thinking was woven throughout the case study research and allowed the participants to gear their lesson design and instruction towards the more relationally inclined students, a practice that Berry (2003) suggests might mediate the challenges these students have with learning in a more traditional mathematics environment.

I am satisfied with the answers the study gave to my original research questions: How does teacher inquiry focused on mathematics instruction and culturally relevant pedagogy impact the attitudes and instructional practices of elementary teachers at a Title 1 school? What changes, if any, do teachers report in their teaching of math throughout the inquiry process? What connections do teachers in an inquiry group report between their study and their students' ability to demonstrate mathematical understanding? Three months after the final session of our inquiry study, participants continued to use poetry, story, and other forms of literacy to engage their students in learning math. They

continued to encourage their students to see that math is part of everything they know and do – shapes in nature, statistics in sports, beats in music, prices in the grocery store, and life equations. The participants continued to revise and revisit lessons that the group explored in order to make sure that their students were developing as mathematicians, not simply doing math.

When I introduced the Rosenthal (2011) book, I did it in a moment of unease. As a group, we were dancing around a particularly uncomfortable conversation on race, and wanting to give myself a little breathing room to figure out a sensitive way to continue, I pulled the *This Plus That: Life's Little Equations* book out of my bag. Throughout the study I regularly shared books that presented interesting ways of looking at math; I thought this picture book was cute and that the teachers would like it, but I never intended it to become the change agent that it has become.

Throughout our study, participants referred to and relied on texts that they had read, especially Ladson-Billings' (1995a) accessible article linking school and culture, *But That's Just Good Teaching! The Case for Culturally Relevant Pedagogy* and Minton's (2007) teacher-friendly *What if Your ABC's Were Your 123's: Building Connections Between Literacy and Numeracy*. It was Rosenthal's (2011) simple picture book text, however, that served as the most accessible, concrete example, giving participants a tool they felt comfortable and confident using with their students. At one point, the participants noted that the lines in the book were poetry-like, because of their use of rhythm and repetition, but it is certainly not a traditional poetry text, and not what I had in mind when I introduced the idea of poetry as a form of culturally relevant

pedagogy. What this text did offer participants was a means to explore their own understanding, and develop a lesson study cycle that allowed them to teach their students the structure of an equation, and explore effective strategies for explaining their thinking by substantiating each component of the equation. This was a foundational mathematical concept taught through language.

Patterns

Devlin (2011) refers to the brain as a remarkable pattern-recognizing device. One of the connections between poetry and mathematics that supported my interest in presenting them together was the reliance on patterns that is common to both. In American public schools, math is generally taught during dedicated math time and poetry is taught in language arts time (often relegated to a unit of study in April during “poetry month”), but the subjects are comparable in many ways. Both math and poetry are often taught through formulaic approaches, a practice that I find often leads to misconception, confusion, and blandness. Both math and poetry use symbols to represent larger or more abstract concepts. Pairing the two made sense as a way of breaking down the walls between two compartmentalized subjects, and allowing students access to higher-level thinking. I was hoping that the five teachers who were part of my case study research would think about their practice differently, and my findings show that they did.

Moving beyond example and observation to the creation of valid proofs is the hallmark practice of mathematicians (Johnson, Watson, Delahunty, McSwiggen, & Smith, 2011). In an interesting study, they explored the way that mathematicians establish mathematical truths by creating patterns and then working to prove those

patterns. This is what the participants in the inquiry study group were attempting to do as well by teaching their students to represent the truth of their lives in equations, and then explain their reasoning and critique the reasoning of their classmates.

Of particular interest for research is the way that students have taken to this equation writing with such enthusiasm. R. Braverman reported this phenomenon taking place in her fourth grade classroom through the following example describing a student:

He loves this equation stuff. Just yesterday when they were filling out the envelopes for their pen pals he wrote two equations on the envelope. One was in relation to some of what was talked about in the letter. That equation was, “computer + free time = fun” and the other was “me + you = penpals.” He clearly loves the idea of thinking about life in terms of equations (personal communication, March 9, 2012).

Recognizing the energy and intellectual engagement that resulted from the presentation of research findings to the staff at NRE, the principal purchased copies of the book for each of the 48 teachers on staff. The books were not distributed with an expectation or directive that the teachers had to use the materials the way that participants had, however, teachers began replicating the group’s lessons the very next day. The day after the group presented our findings to the staff at NRE, a mentor teacher wrote this email:

Thank you so much for sharing your work at the staff meeting yesterday. It was so interesting. I am so excited about the ways that you are working with math, literacy, and deepening thinking.

I found myself thinking in equations this morning (yard duty + wind=bad hair day) (personal communication, March 7, 2012).

A science teacher on site reported that she taught the equation lesson to her Special Day students and that she was amazed by how successful they were at demonstrating their thinking about science. This strategy gave the students a concrete way to share their knowledge. The excitement of the teacher presenting the lesson resulted in curious and engaged young scientists. Similarly, one day after I shared a conversation about the lesson study with a group of high school English teachers, a young twelfth grade teacher emailed me to report that her students had written incredibly thoughtful and complex equations about truth while reading *1984* (Orwell, 1949).

As a result of the inquiry group's work, teachers across grade levels, across the district, across the state, and across the country introduced this language arts work into their math instruction and the math work into their language arts, social studies, and science work (see Appendix E). I've spent a lot of time reflecting on what it is that makes this engaging and compelling work for students and teachers alike.

Reflection and Implications

It has been well established that school mathematics, as it has been traditionally taught, often fails to consider relevance. Without the connection to life, many students, particularly African American boys, struggle (Berry, 2003; Bol & Berry, 2005; Tate 1995). Kwako (2011) explains that real life issues can provide rich contexts for learning mathematics, serving to build motivation and pleasure in the learning process for

students. Separating math from reality can actually be harmful, teaching students that math does not matter in their lives when it in fact, surrounds them.

Participants found that introducing this focus on language and real-life equations provided the necessary connection to make the math work relevant; the practice of teachers in other disciplines beginning to use the language of math equations in their instruction continued this paradigm shift. In the common analogy that defines mathematics as a gateway to the future, and traditional math instruction as a lock on that gate, I considered this change in attitude and practice as a cracking open of the gate, a recognition that learning could be, and should be, an inter-disciplinary endeavor. As a researcher, while I have tended to look at this process as one that is filled with promise, I am also aware of the challenges and issues that it poses.

It is possible to look at the equations generated by students and teachers and think, so what? Equations that do not refer to numbers are not math. This was a fear that the inquiry study group wrestled with initially when making the decision to begin our work at the conceptual level before introducing numbers. As a result of this study, students who were struggling with math proficiency and did not necessarily think of themselves as mathematicians began thinking in equation. They began exploring connections between language and math, pattern and math, their lives and math. This work had a similar impact on the participants who are the practitioners in the classroom. Their change in attitude led to a definite change in practice. My fear is not that these teachers will lose sight of the research and revision that went into their lessons, but that their work might become diluted or misinterpreted when adopted by others. Ideas that

developed and deepened over several months of close study among participants will not necessarily transfer to other situations.

In discussing the power of this work with others, I sometimes get an uneasy feeling, harkening back to the issues that arose when whole-language instruction took the place of phonics and decoding in reading instruction decades ago. One form of instruction was never intended to replace the other, but rather the two were designed to work in tandem, strengthening the reading skills and the engagement of students. This study does not mean to suggest that poetry and language arts should replace direct explicit math instruction, but rather, that together, these might strengthen the skills and engagement of students. Considering the cultural relevance of their instruction had a profound impact on the attitudes and practices of the participants in this study, but taken out of context, it could work to undermine student learning. A math curriculum based too much on language arts will not help students to become stronger mathematicians.

Additionally, the limitations of this study include the geographical location, the length of the project, and the selection criteria, gender, and ethnicity of the participants.

Recommendations for Further Study

In my experience as a literacy coach, I have experienced the cyclical process of learning, and recognize the attention that must be paid to ensuring that research, inquiry, and collaboration continue beyond the scope of the study. This study reflects the work conducted by recognized scholars and practitioners in the study of poetry, culturally relevant mathematics instruction, and teacher inquiry, and it does so through the lens of Critical Race Theory. It is however, an admittedly narrow study, examining the attitudes

and practices of five teachers at one Title 1 elementary school in one suburban school district in northern California. While this study yielded findings related to the attitudes and practices of teachers in a participatory action research case study, there are additional ways to contribute to the literature and to the existing lesson study models of teacher inquiry.

The teachers who participated in the study were interested in examining their attitudes and practices, they were open to experiencing other ways of teaching and being, and they were committed to developing a deeper understanding of cultural relevance while exploring their own cultural awareness. They reported experiencing a paradigm shift through this study and they have changed their approach to mathematics instruction in ways that will continue to support the growth of all students. It is important that these participants continue their work together, looking at next steps for keeping math instruction relevant and rigorous, and ensuring that student engagement and success as mathematicians is sustained. Steinberg et al. (2004) concluded that ongoing learning through practice and collaborative study is an essential mechanism for reform.

In addition to expanding this work at NRE, there is a need to bring this work to sites where the climate for growth and learning is less focused on engagement and cultural relevance. In educational environments where students of color who struggle in math are given little hope of experiencing academic success, and no hope of building math identities, this type of study is even more necessary. The reliance on traditional instruction, worksheets, and remedial drills that define the math experiences of so many African American youth need to be overturned; it is this type of instruction that calls into

question the morality of academic tracking and what Beers (2009) classifies as segregation by intellectual rigor.

Ladson-Billings (1995b) contends that academic achievement and cultural competency can work hand-in-hand to deliver African American students from the shackles of intellectual inequity. Given that the lower mathematics achievement levels of minority students is tied to the curriculum and instruction that they receive, there needs to be more funding committed to researching the kinds of instruction that make a difference. In addition to research funding, professional development models built on cycles of teacher inquiry and facilitated by expert others, should be developed and instituted in teacher preparation programs at Institutes of Higher Learning and in public school settings, urban, suburban, and rural. Ultimately, cross-curricular models of instruction should become the norm. The time is ripe for such an endeavor; the development and subsequent adoption of the Common Core State Standards Initiative with its focus on interdisciplinary literacy may provide an opportunity to de-compartmentalize learning and to reform and reframe curriculum and instruction to ensure that all students count.

What, after all, is mathematics but the poetry of the mind, and what is poetry but the mathematics of the heart?
David Eugene Smith (1906)

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APPENDIX A

CONTINUUM OF TEACHING PRACTICE: THE ESSENTIAL ELEMENTS

Participant: _____

Date: _____

Essential Element	Evidence	Emerging	Exploring	Applying	Integrating	Innovating
<p>1.4 Using a variety of instructional strategies, resources, and technologies to meet students' diverse learning needs</p>		<p>Uses instructional strategies, resources, and technologies as provided by school and/or district.</p> <p>Some students participate in instructional strategies using resources and technologies provided.</p>	<p>Explores additional instructional strategies, resources, and technologies in single or sequence of lessons to meet students' diverse learning needs</p> <p>Students participate in single or sequence of lessons related to their interests and experiences.</p>	<p>Utilizes a variety of strategies including culturally responsive pedagogy, resources, and technologies during ongoing instruction to meet students' diverse learning needs.</p> <p>Students participate in instruction using strategies, resources, and technologies matched to their learning needs.</p>	<p>Creates, adapts, and integrates a broad range of strategies, resources, and technologies into instruction designed to meet students' diverse learning needs.</p> <p>Students actively engage in instruction and make use of a variety of targeted strategies, resources, and technologies to meet their individual learning needs.</p>	<p>Refines the flexible use of an extensive repertoire of strategies, resources, and technologies to meet students' diverse learning needs.</p> <p>Students take responsibility for using a wide range of strategies, resources, and technologies that successfully advance their learning.</p>
<p>2.3 Establishing and maintaining learning environments that are physically, intellectually and emotionally safe</p>		<p>Adheres to policies and laws required by the site, district and state regarding safety. Responds to behaviors that impact student safety as they arise. Students are aware of required safety procedures and the school and classroom rationale for maintaining safety.</p>	<p>Recognizes and addresses safety issues regarding materials, student interactions, and the organization of the learning environments. Explores strategies to establish intellectual and emotional safety in the classroom. Students follow teacher guidance regarding safety issues for self or others.</p>	<p>Anticipates and reduces risks to physical, intellectual, and emotional safety using multiple strategies that include examining biases in the learning environment and curriculum. Models and provides instruction on skills that develop resiliency and support intellectual and emotional safety. Students take risks, offer opinions, and share alternate perspectives.</p>	<p>Integrates support for students to take risks and offer respectful opinions about divergent viewpoints. Engages in reflection on their own language and behavior that contributes to intellectual and emotional safety in the classroom. Students develop and practice resiliency skills and strategies to strive for academic achievement, and establish intellectual and emotional safety in the classroom.</p>	<p>Shares responsibility with the students for the establishment and maintenance of a safe physical, intellectual and emotional environment focused on high quality and rigorous learning.</p> <p>Students demonstrate resiliency in perseverance for academic achievement. Students maintain intellectual and emotional safety for themselves and others in the classroom.</p>

APPENDIX A

CONTINUUM OF TEACHING PRACTICE: THE ESSENTIAL ELEMENTS

Essential Element	Evidence	Emerging	Exploring	Applying	Integrating	Innovating
<p>2.6 Employing classroom routines, procedures, norms, and supports for positive behavior to ensure a climate in which all students can learn.</p>		<p>Establishes procedures, routines or norms for single lessons to support student learning.</p> <p>Responds to disruptive behavior.</p> <p>Students are aware of procedures, routines, and classroom norms.</p>	<p>Develops routines, procedures and norms in a sequence of lessons with some student involvement.</p> <p>Seeks to promote positive behaviors and responds to disruptive behavior.</p> <p>Students receive correction for behavior that interferes with learning, and positive reinforcement in following routines, procedures and norms.</p>	<p>Maintains regular use of routines and procedures that are culturally responsive.</p> <p>Engages students in the development and monitoring of norms.</p> <p>Provides positive behavior supports. Responds appropriately to behaviors in ways that minimize disruptions to the learning climate.</p> <p>Students participate in routines, procedures in norms and receive reinforcements for positive behaviors. Students receive timely and effective feedback and consequences for behaviors that interfere with learning.</p>	<p>Engages students in monitoring and reflecting on routines, procedures and norms in ways that are culturally responsive. Maintains a quality learning climate that builds on student strengths.</p> <p>Promotes positive behaviors and consistently prevents or refocuses disruptive behaviors.</p> <p>Students are involved in assessment and monitoring of routines, procedures and norms in ways that improve the learning climate.</p>	<p>Facilitates student participation in developing, monitoring and adjusting routines and procedures focused on maximizing learning.</p> <p>Classroom climate integrates school standards and culturally relevant norms.</p> <p>Promotes positive behaviors, establishes preventions and a positive classroom climate that eliminate most disruptive behavior.</p> <p>Students share responsibility with teacher for managing and maintaining a positive classroom climate that promotes learning.</p>
<p>3.5 Using and adapting resources, technologies and standards-aligned instructional materials, including adopted materials to make subject matter accessible to all students.</p>		<p>Uses available instructional materials, resources, and technologies for specific lessons to make subject matter accessible to students.</p> <p>Identifies technological resources needed.</p>	<p>Explores additional instructional materials, resources and technologies to make subject matter accessible to students.</p> <p>Explores how to make technological resources available to all students.</p>	<p>Selects, adapts, and utilizes appropriate instructional materials, resources and technologies for concept and skill development in subject matter. Resources reflect the diversity of the classroom and support differentiated learning of subject matter. Guides students to use available print, electronic and online subject matter resources based on individual needs.</p>	<p>Integrates a wide range of adapted resources, technologies and instructional materials to meet identified student needs and make subject matter accessible to students.</p> <p>Assists students with equitable access to materials, resources and technologies. Seeks outside resources and support.</p>	<p>Engages students in identifying and adapting resources, technologies and stands-aligned instructional materials to extend student understanding and critical thinking about subject matter.</p> <p>Ensures that students are able to obtain equitable access to a wide range of technologies, through ongoing links to outside resources and support.</p>

APPENDIX A

CONTINUUM OF TEACHING PRACTICE: THE ESSENTIAL ELEMENTS

Essential Element	Evidence	Emerging	Exploring	Applying	Integrating	Innovating
<p>4.1 Using knowledge of students’ academic readiness language proficiency, cultural background, and individual development to plan instruction.</p>		<p>Plans daily lessons using available curriculum and information from district and state required assessment.</p> <p>Is aware of the impact of bias on learning.</p>	<p>Plans single or sequence of lessons using additional assessment information on student academic readiness, language, cultural background, and individual development.</p> <p>Becomes aware of potential areas of bias and seeks to learn about culturally responsive pedagogy.</p>	<p>Plans differentiated instruction based on knowledge of students’ academic readiness, cultural backgrounds, and individual cognitive, social, emotional and physical development to meet their individual needs.</p> <p>Examines potential sources of bias and stereotyping when planning lessons.</p> <p>Uses culturally responsive pedagogy when planning.</p>	<p>Plans differentiated instruction which is based on broad knowledge of students. Matches resources and specific strategies to students’ diverse learning needs and cultural backgrounds.</p> <p>Planning addresses bias, stereotyping, and assumptions about cultures and members of cultures.</p>	<p>Plans differentiated instruction that provides systematic opportunities for supporting and extending student learning based on comprehensive information on students.</p> <p>Engages students in the analysis of bias, stereotyping and assumptions.</p>
<p>4.4 Planning instruction that incorporates appropriate strategies to meet the learning needs of all students.</p>		<p>Plans instruction that incorporates strategies suggested by curriculum guidelines.</p> <p>Is aware of student content, learning and language needs through data provided by the site and district.</p>	<p>Selects strategies for single or a sequence of lessons that respond to student’ diverse learning needs.</p> <p>Seeks to learn about students’ diverse learning and language needs beyond basic data.</p>	<p>Infuses differentiated instructional strategies into ongoing planning that addresses culturally responsive pedagogy, students’ diverse language and learning needs and styles.</p>	<p>Plans instruction using a wide range of strategies to address learning styles and meet students’ assessed language and learning needs. Provides appropriate support and challenge for students.</p> <p>Integrates results from a broad range of assessments into planning to meet students’ diverse learning and language needs.</p>	<p>Plans instruction incorporating repertoire of strategies to specifically meet students’ diverse language and learning needs and styles to advance learning for all.</p> <p>Facilitates opportunities for students to reflect on their learning and the impact of instructional strategies to meet the learning and language needs.</p>

APPENDIX A

CONTINUUM OF TEACHING PRACTICE: THE ESSENTIAL ELEMENTS

Essential Element	Evidence	Emerging	Exploring	Applying	Integrating	Innovating
<p>5.4 Using assessment data to establish learning goals and to plan, differentiate, and modify instruction.</p>		<p>Uses data from assessments provided by site and district to set learning goals for the class.</p> <p>Plans instruction using available curriculum guidelines.</p>	<p>Uses data from available assessments to establish content based learning goals for class and individual students in single of sequence of lessons.</p> <p>Plans adjustment in instruction to address learning needs of individual students.</p>	<p>Uses a variety of assessment data to set student learning goals for content and academic language that are integrated across content standards for individuals and groups.</p> <p>Plans differentiated instruction targeted to meet individual and group learning needs and modifies lessons during instruction based on informal formative assessments.</p>	<p>Uses a broad range of data to set learning goals for content and academic language that are integrated across content standards for individuals and groups.</p> <p>Plans differentiated instruction targeted to meet individual and group learning needs and modifies lessons during instruction based on informal assessments.</p>	<p>Reflects on data continuously to make ongoing refinements to learning goals for content and academic language for the full range of students.</p> <p>Uses data systematically to refine planning, differentiate instruction and make ongoing adjustments to match the evolving learning needs of individuals and groups.</p>
<p>6.3 Collaborating with colleagues and the broader professional community to support teacher and student learning.</p>		<p>Attends staff, grade level, department, and other required meetings and collaborations.</p> <p>Identifies student and teacher resources at the site and district level.</p>	<p>Consults with colleagues to consider how best to support teacher and student learning.</p> <p>Begins to identify how to access student and teacher resources in the broader professional community.</p>	<p>Collaborates with colleagues to improve student learning and reflect on teaching practice at the classroom level.</p> <p>Interacts with members of the broader professional community to access resources that support teacher effectiveness and student learning.</p>	<p>Collaborates with colleagues to expand impact on teacher and student learning within grade or department and school and district levels.</p> <p>Engages with members of the broader professional community to access resources and a wide range of supports for teaching the full range of learners.</p>	<p>Facilitates collaboration with colleagues,</p> <p>Works to ensure the broadest positive impact possible on instructional practice and student achievement at school and district levels and for the profession.</p> <p>Initiates and develops professional learning opportunities with the broader professional community focused on student achievement.</p>

APPENDIX B

POEMS WRITTEN BY THIRD GRADE STUDENTS FOLLOWING LESSON ON
POEMS FOR TWO VOICES

Association

Association

Association

Organizing

Re-organizing

Grouping

Switching Groups

Association

Association

Changing groups

But not the big group

The all together is the same

Association

Association

Breaking friendships

Making friendships

The big group

Stays the same

With different clubs

The whole is the same

Exactly

Association

Association

APPENDIX B

POEMS WRITTEN BY THIRD GRADE STUDENTS FOLLOWING LESSON ON
POEMS FOR TWO VOICES

Multiplication

It's about groups

Joining equal groups

Like addition

Adding and adding and adding

Only faster

Easier

Just remember

2s, 5s, and 10s are easiest

Multiplication

Like addition

Joining equal groups

Multiplication

Multiplication

APPENDIX C

UNDERSTANDING EQUAL LESSON, FIRST GRADE

Title of lesson: Understanding Equal

Goal: students will demonstrate and understanding of the mathematical term equal and explain their thinking, and critique the reasoning of others

Why teach it

- We notice that our students are strong in computation and memorization, but struggle with articulating the process and explaining their thinking.
- Students see math in isolation instead of contextually

How does understanding of the topic develop?

- K Equal means the same
- 1 Intro of the sides being the same balance
- 2 Balance
- 3 Equality symbol, inequity in relation to larger numbers
- Compare and contrast
- 4 Complexity increases, fractions and decimals

1 Standards

1.2 Understands the meaning of the symbols $+$ $-$ $=$

2.1 Explain the reasoning used and justify the procedure selected.

Lesson Design

Read *This Plus That*

Teacher describes what is fun for her and shows her page

Shopping + peppermint mocha=fun

Family + movies=fun

For her son Home + lego= fun

Students come up with their own examples

Teacher charts a sampling

Teacher models explaining her thinking and critiquing others using sample of her son.

Teacher references accountable talk

Students chosen from chart explain their thinking

Others Critique

APPENDIX C

UNDERSTANDING EQUAL LESSON, FIRST GRADE

Students will create their own equations

- Illustrate and explain their thinking
- Work independently use any topic or subject

Students given a post it, go on gallery walk

Agree or disagree

Other students critique.

APPENDIX D

UNDERSTANDING EQUAL LESSON, FIRST GRADE REVISED
GRADE LEVEL: 1ST

1. Title of lesson:

Understanding Equal

2. Research Theme:

Constructing Viable Arguments and Critiquing the Reasoning of Others

Broad Goal: Students will no longer look at math in isolation, but realize that it is all around them. Students will develop a lifelong connection to math.

Lesson Goal: Students will explore the concept of equal and equation, explain their thinking, and critique the reasoning of others.

3. Lesson Rationale:

Three key observations were:

- Our students are strong in computation and memorization, but struggle with articulating the process and explaining their thinking.
- Students see math in isolation instead of contextually
- When students go to explain their mathematical thinking, they often leave out some important key parts of their reasoning.

We designed our lesson using a picture book to introduce the concept of **equal** and **equation** in a child friendly way. We modeled those two concepts using the context of our own lives and then asked students to explore those same concepts in relation to their own lives through the construction of “life equations.” We also asked them to justify their thinking about their life equations. We see this lesson as an important scaffold for students to be able to justify their mathematical thinking with numbers in the future.

4. How does students’ understanding of the topic develop?

- K- 1 to 1 correspondence through use of concrete objects. Introduction of vocabulary. Decomposing numbers, introduction of equals sign, composing a number sentence. Explanation of reasoning with concrete objects or pictorial representation.
- 1- Understanding of the meaning of the term, ‘number sentence’ by extracting information and putting it into the number sentence. Introduction of the concept of fact families and how numbers are related. Explanation of reasoning with concrete objects or pictorial representation and check their work.
- 2- Being able to manipulate numbers to create balance on either side of the equals sign. Defend the reasoning use and justify the procedures selected.

APPENDIX D

UNDERSTANDING EQUAL LESSON, FIRST GRADE REVISED
GRADE LEVEL: 1ST

- 3/4- Equal symbol, balancing equations using multiple operations. Use of more complex kinds of numbers. (decimals and fractions) Use a variety of methods such as words, numbers, symbols, charts, graphs, tables, diagrams, and models to explain mathematical reasoning. Evaluate the reasonableness of the solution in the context of the original situation.

5. Relationship of the Lesson to State Standards:*1st Grade Standards:*

- 1.2 Understands the meaning of the symbols + - =
 2.1 Explain the reasoning used and justify the procedure selected.

Lesson Design

Student Activities		Teacher support	Points of Evaluation
Intro		Teacher: What does equal mean? (Just think time) Show cover title and explain. Amy + Krouse + Rosenthal= writer.	
Read Text Student interaction	Students turn and talk	Read <i>This Plus That</i> <ul style="list-style-type: none"> • Movie page pause for them to complete • Read fall and winter then have them guess spring and summer) • Depending on class • my gosh you are getting so good at equations. • Finish book 	Do students begin to anticipate reasonable responses?

APPENDIX D

UNDERSTANDING EQUAL LESSON, FIRST GRADE REVISED
GRADE LEVEL: 1ST

After Reading	Students turn and talk	So what do you think Equal means? Chart some student answers- think time turn and talk.	Are students bringing in numbers? Are students generating definitions with example?
Modeling Equations	Students turn and talk	Teacher Model on chart paper Friday dinner out + movie My son would disagree Soccer + pizza + ice cream = Fun. Teacher example of daughter Recess + friends – whistle = Fun Turn and talk Are you thinking of one right now? Think of your own equation; it can be for fun or any thing. Share out	Are students creating and articulating their own equations?
Students work at tables	Students work at tables	Now you are going to go back to your seat create your own equation, Remember just like the book, your equation can be about anything. Explain your thinking and illustrate your thinking. Early finishers do a second one.	Are student equations different from the ones they had on the carpet? Are they doing multiple examples? Do they revise as they write?

APPENDIX D

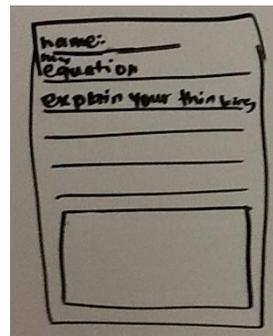
 UNDERSTANDING EQUAL LESSON, FIRST GRADE REVISED
GRADE LEVEL: 1ST

Critique lesson	Students turn and talk	<p>Students leave work on tables Gather at the rug</p> <p>We are going to look at some of our classmates equations and critique each others thinking</p> <p>Demonstrate on the examples Reference accountable talk poster. This is what my son said:</p> <p>Turn and talk: Practice critiquing daughter example with partner. Students will gallery walk and critique on post-its. (post-its in the middle of the table) Remind them to put their name on their post-it</p>	<p>Are students using accountable talk?</p> <p>Are they elaborating their thinking?</p>
Critique Student practice		<p>Teacher looks for 2 examples for share out.</p> <ul style="list-style-type: none"> • Student shares equation and thinking • Agreeing student shares critique • Disagreeing student shares critique 	<p>Are students using accountable talk?</p> <p>Are they modifying each other's equations?</p>
Close		<p>Close: math is all around us.</p> <p>You have done such a great job thinking like mathematicians.</p> <p>I hope you enjoyed writing our own life equation I loved the way you shared your ideas about this.</p> <p>I have a great idea lets make a book so we can share our good thinking with each other.</p>	

APPENDIX D

UNDERSTANDING EQUAL LESSON, FIRST GRADE REVISED
GRADE LEVEL: 1ST**Supplies**

Chart for accountable talk
Charts with examples of equations done
Post its with examples of critiques
Student paper and post-its



APPENDIX E

A TEACHER INQUIRY MODEL – BEYOND DATA COLLECTION

