USING NUMBER TALKS TO ADDRESS STATUS AND SELF-THEORIES IN A FOURTH GRADE CLASSROOM

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ABSTRACT

There are many reasons elementary school students struggle in mathematics, from less than optimal instructional practices, to negative teacher's beliefs, lack of culturally relevant teaching, low social and academic status effects in the classroom, and negative self-theories. Number talks present a container practice that can be used to work to address these and other limits on student achievement in math. This action research project investigates the effect of number talks on measured and expressed student status and self-theories over the course of the study period. Number talks can be a tool for teachers to only only promote higher levels of mathematical understanding and achievement by doing math, but by addressing teacher and student beliefs about themselves and their peers. During the course of this project, I assessed student's status and self-theories to look for patterns of change. I conducted follow-up interviews with students to get a finer grained picture of their feelings of the effect of number talks. My analysis shows that both status effects and self-theories for students shifted in overall significantly positive directions, and data pointed to number talks as a key ingredient in this shift. I recommend that teachers take up the practice as a tool for improving student outcomes. Mitigating status and changing self-theories has the potential for raising math and other academic achievement, as well as positively impacting students overall experiences in the classroom.

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CHAPTER 1 — INTRODUCTION AND LITERATURE REVIEW

Changing Views On Math

My suburban, fourth grade math classroom, is a representative slice of the nation's public school nine and ten year-olds. Most, when asked, do not cite mathematics as their favorite subject, and by the sometimes tired looks, the frequent disengagement, and the mediocre assessment results in my class, I can see why. It is hard for students to enjoy mathematics when many perceive themselves to be unsuccessful and struggle to access the concepts and ideas. With math traditionally taught as memorization of discrete facts often disconnected from their everyday lives, it is easy to see why it might feel tedious to listen to the lectures and fill out the worksheets of a typical mathematics class. However, I don't believe that math is boring, overly factual, or disconnected from real life. Mathematics as a language that takes place in multiple forms all around us at all times, a language hidden in plain sight. I believe that math can be understood better if approached critically, with a sense of inquiry, where seeking of conceptual knowledge and understanding is encouraged, not just reward of speed and memorization. For students to approach mathematics in an inquisitive way, for them to be aware of the potential joys and uses of the subject, we need to think about teaching math differently.

Teaching practices and instructional activities are critical aspects of educating students about math because they communicate a framework for learning math (Featherstone, Crespo, Jilk, Oslund, Parks, & Wood, 2011; Van de Walle, Karp, & Bay-Williams, 2010). Teaching practices are not just the nuts and bolts of instruction, they are also the less tangible side of mathematics. Teaching practices communicate a teacher's beliefs about themselves and their students, beliefs about the nature of math itself and most importantly, how people can and should be doing math (Zohar, Degani, & Vaaknin, 2001). These practices and activities can either make math more equitable and accessible, or they can perpetuate math as a disconnected, elite activity relegated mainly to high-achieving, high-status students (Featherstone et al., 2011). The continuing societal trend is toward increasing technological complexity, and progressively higher levels of education appear to be a key component in achieving social mobility. Therefore, making challenging math accessible to students literally opens a gateway to success that would otherwise be closed.

Why Is Math So Hard

Although one need not travel far to find teachers who believe most students are just never going to be able to do challenging math, many experts in the field believe the range of people who can succeed at complex math is very wide, especially if given opportunities with appropriate support in classrooms where students of mixed abilities are held to consistently high expectations (Boaler, 2002; Featherstone et al., 2011; Van de Walle et al., 2010). Boaler (2002) found that a school where academic tracking — that is, segregating students by ability level — was not employed demonstrated that low-achieving students placed in high-expectation classrooms were able to perform complex math successfully.

Beliefs held by teachers and students in the classroom also lead to effects on status characteristics. "A status characteristic is an agreed-upon social ranking where everyone feels it is better to have a high rank than a low rank. Examples of status characteristics are race, social class, sex, reading ability, and attractiveness" (Cohen, 1994, pg. 28). Cohen (1994) points out that status is often irrelevant of ability to correctly complete the task. A student with high social status who is wrong about how to solve a math problem will override a low-status student who may have a correct way of getting to a mathematical solution but who is prevented from expressing it. In the book S*marter Together!*, Featherstone (2011) and her colleagues focused their combined decades of classroom and research experience to show that status plays a large, if often invisible, part in increasing or inhibiting student learning. Taking steps to minimize status effects, traditionally low-status students can improve their access to complex math while simultaneously, high-status students in heterogeneous (mixed-ability) classrooms can learn even more (Boaler, 1998). Van de Walle et al.'s (2010) instructional text based on years of research and experience discusses many techniques that can help students of differing ability levels be successful at complex mathematics. According to Van de Walle et al. (2010), through correct implementation of scaffolding, and basic techniques such as differentiating content for a range of learning abilities and needs, complex mathematics can be made more accessible to students with linguistic barriers, as well as students with mild and moderate learning disabilities. A major theme of the research is that students' approach to complex math is generally aided by the presence of dialogic patterns of discussion where a variety of individuals employing different strategies for the same problem are encouraged to explain and defend their reasoning to others (Parrish, 2010; Kazemi & Stipek, 2001; Gnadinger, 2007; Truxaw & DeFranco, 2008).

Research has shown that students gain better proficiency at math if it is delivered to them as an inquiry-based practice where questioning, reflection and group processing are implemented as part of the process (Bertucci, Johnson, Johnson, & Conte, 2012; Gnadinger, 2007; Hufferd-Ackles, Fuson, & Sherin, 2004; Kazemi, 1998; Morrone, Harkness, & Caulfield, 2004; Truxaw, 2008). It is important to focus on understanding through group participation and dialogue where students are co-creators of understanding instead of maintaining traditional, memorization-based practices where students are expected to be passive recipients of teacher knowledge (Stipek, Givvin, Salmon, & MacGyvers, 2001). Paulo Freire, a famous proponent of student-centered educational theory, posits that teacher and student are co-creators of knowledge that arises organically from a process in which teachers are learning, and learners are teaching (Freire, 1998). This often plays out in what Freire calls problem-posing education which rests firmly on patterns of questioning and critical thinking by both teacher and students. To this end, students benefit from questioning strategies designed to elicit their understanding (Kazemi & Stipek, 2001), through classroom conversations around understanding math (Morrone et al., 2004) and by engaging in ongoing reflection about their own problem solving processes (Bertucci et al., 2012).

Counteracting barriers to students learning math is both possible and imperative. This can be accomplished with student-centered teaching practices that model positive teacher beliefs about students' ability to learn (Boaler, 2002; Stipek et al., 2001), minimize negative status effects (Featherstone et al., 2011), and that increase students' positive self-theories (Dweck, 2000). In order to affect this type of learning, I needed an instructional practice that allowed many complex interactions to happen simultaneously, that highlighted my belief that all students could learn challenging math, and that all students had something of value to bring to discussions about math. I needed an instructional practice that allowed the students in my classroom to engage with math in a different way, one that showed them there are many valuable perspectives, that fostered critical thinking, and that demonstrated that although everyone starts at different place in relation to a problem, all can succeed in making progress toward understanding and solutions. For the fourth graders in my classroom, I needed an instructional process that had a lasting positive impact, that changed students' views of themselves and their peers, and challenged and empowered each of them mathematically, regardless of their status or ability level. I believed I'd found that instructional process in *number talks*.

Number Talk Potential

While researching the problems currently affecting math instruction and searching for socially constructive, student-centered solutions, the recent practice of number talks emerged as a potential solution. While I could find no available peer-reviewed research, I immediately saw their potential. Number talks addressed many of the problems that create barriers for students learning math because they highlight multiple perspectives, foster critical thinking and discussion opportunities, expose students to a variety of ideas in a problem-posing setting, and give teachers opportunities to become aware of and start to mitigate issues of low and negative self-theories. This potential to address status issues and self-theories became the focus of this action research project.

A number talk is a student-centered group activity that approaches mathematics instruction in a novel way, especially when contrasted with traditional curricula. Using graphics, patterns, and charts, a number talk creates a hands-free, conceptual lesson designed to engage students to think in a variety of ways about a mathematical concept, as well as interacting in a group to elucidate their thinking. Number talks provide teachers with a way of priming students for study of new mathematical concepts, as well as bringing established ideas full-circle, thereby encouraging student discovery of new ways to look at the same thing. Number talks can allow for social and developmental work to be facilitated by the teacher. For example, teachers can use this forum to work on group dynamics, to impart views on student ability and effort, to validate diverse perspectives, to show the class as a collection of equally valuable individuals, and to heighten engagement and a sense of community.

Review of the Literature

In the following literature review, I outline in depth some of the common problems with math instruction. In the *Looking For A Solution* section, I provide a detailed explanation of the potential for number talks to mitigate problems. Although there are many barriers to effective mathematical instruction in elementary schools, number talks can play a crucial role in providing teachers with tools to break down those barriers so all students have access and can learn math.

Instructional Practices

Before reviewing the impact of how both teachers' and students' biases and beliefs impact their participation and status in the classroom, it is important to understand the larger structures and practices in which these beliefs and interactions unfold, particularly institutional instructional practice. Mathematics is traditionally delivered via teacher-centered instruction that focuses on speedy production of correct answers rather than a deeper, complex understanding of mathematical principles (Stipek et al., 2001; Boaler, 1998). This type of instruction can make math boring and inaccessible to all but a few while also making math seem disconnected from regular life. Teacher-centered education presents instructors as experts who deliver knowledge to passive student recipients, which often accounts for much of the disengagement and seat-squirming of an elementary math classroom. Loss of freedom, choice and autonomy has been shown to decrease student motivation to engage in tasks because it reinforces extrinsic rewards and decreases intrinsic motivation (Deci, 1995). Also, according to Zull (2002), full engagement in learning includes cognitive processing, activation of prior knowledge, and physical activity as opposed to listening passively to instruction. Removal of the student from direct engagement has the effect of decreasing a student's ability to intake, process, and incorporate new knowledge.

Teachers who believe in inquiry-based, student-centered teaching can implement these effective types of classroom environments. Teaching strategies that are inquiry-based are more intrinsically motivating and student-centered (Stipek et al., 2001) and implementation of student-centered education can increase quantity and quality of complex student thought and interactions (Wood, Williams, & McNeal, 2006). Additionally, socially constructed teacher practices can promote mastery goals via scaffolding, “high-press questioning” (Kazemi & Stipek, 2001) and higher-order thinking (Morrone et al., 2004).

Another key aspect of an effective mathematics learning community is peer collaboration. This happens when students are encouraged to work together to formulate answers, to question each other and to provide scaffolding for co-learning. In this way, peer collaboration can be a significant source of a student’s teaching and learning (Gnadinger, 2007; Bertucci et al., 2012). However, effective peer collaboration is not a haphazard enterprise. Teachers must facilitate intentional, structured collaboration with student-centered, group-worthy tasks to see benefits (Gnadinger, 2007). It should also be noted that student-centered collaborative instruction is not the norm in most schools and students unaccustomed to these techniques will often resist at first, giving a misleading impression that the process is ineffective or counterproductive. It is imperative to stick with collaborative group processes long enough for students to overcome their initial resistance to new methods (Cohen, 1994; Featherstone et al., 2011).

Other key aspects of an effective math learning community are high-level discourse (Truxaw, 2008), and exposing all students to challenging math in heterogeneous, cooperative settings (Stevens & Slavin, 1995; Zohar et al., 2001). Students must also be provided opportunities to co-process their learning and debrief with peers (Bertucci et al., 2012; Hufferd-Ackles et al., 2004). With proper teacher facilitation, students can learn as much or more from themselves and their peers as they do from direct instruction.

How the teacher facilitates classroom thinking and dialogue has a large effect on outcomes and technique is critical in achieving a highly productive environment with deep, complex thinking (Kazemi & Stipek, 2001; Kazemi & Hintz, 2014; Chapin, O'Connor, & Anderson, 2013). For example, in a study of several classrooms, Kazemi & Stipek (2001) found that subtle differences in teaching practices created dialogue and questioning patterns that either led to typical, surface level explanation of concepts and processes, or to deeper, more complex thinking. Key to achieving deeper thinking was what the authors refer to as "high-press questioning", along with some explicit sociomathematical norms:

a. "An explanation consists of mathematical argument, not simply a procedural description or summary
b. mathematical thinking involves understand relations among multiple strategies
c. Errors provide opportunities to reconceptualize a problem, explore contradictions in solutions, or pursue alternative strategies
d. Collaborative work involves individual accountability and reaching consensus through mathematical argumentation" (p.64)

The authors stated that, "Quantitative findings, reported elsewhere, showed a significant positive correlation between the degree of press in the observed lessons and growth in students' conceptual understanding..." (Kazemi & Stipek, 2001, p.61). Morrone et al. (2004) similarly found that teachers are effective at promoting conceptual, higher-order mathematical thinking when they use questioning patterns that support and extend students' thinking, while pressing them for deeper understanding.

It is important to realize the importance of mathematical discussion — people engaging in verbal exchange of ideas — versus traditional instruction by lecture and independent practice. Although guided instruction and practice are important, verbal engagement and exchange around math is necessary for learning to happen. In two detailed books on the subject of setting up and leading mathematical discussions, Kazemi & Hintz (2014) and Chapin et al. (2013) lay out goals and benefits for robust mathematical dialogue and exchange, summarized in Table 1.1.

Table 1.1

Goals and Benefits of Robust Mathematical Discussions

Goals	**Benefits**
Principle 1: Discussions should achieve a mathematical goal	1. Talk can reveal understanding and misunderstanding.
Principle 2: Students need to know what and how to share	2. Talk supports robust learning by boosting memory.
Principle 3: Teachers need to orient students to one another and the mathematical ideas	3. Talk supports deeper reasoning.
Principle 4: Teachers must communicate that all students are sense makers and that their ideas are valued	4. Talk supports language development.
	5. Talk supports development of social skills
(Kazemi & Hintz, 2014, p.4-5)	(Chapin et al, 2013, p.xv)

Effective dialogue is an important means of achieving deeper understanding. Classroom dialogue can be broken down along a continuum from univocal (teacher-centered, information delivery) to dialogic (student-centered, problem-posing)

(Truxaw & DeFranco, 2008). Univocal interactions are deductive and feature merely answering questions, not moving beyond them to greater meanings. Dialogic interactions, by contrast, move “inductively beyond an answer to the original question [and] toward mathematical meaning-making” (p.514). Teachers’ actions affect where along the univocal-dialogic continuum classroom interactions will fall, thereby directly affecting students’ opportunities to make complex meaning of mathematical concepts versus merely finding answers.

Implementation of student-centered, complex, dialogic, high-press learning techniques is challenging, yet achievable. Use of a framework, such as sociomathematical norms, can be helpful for teachers in developing a classroom learning community that stimulates learning by engaging students and teacher in meaningful discourse (Hufferd-Ackles et al., 2004).

Teacher Beliefs

When looking at students’ ability to succeed in an often frustrating subject like math, we must begin by addressing teachers’ beliefs about their students and the subject matter at hand. Teachers have enormous power in shaping classroom dynamics (Featherstone et al., 2011), and their beliefs affect the way they teach, and the way they implement instruction (Stipek et al., 2001). If teachers do not have a passion for mathematics and a high level of content knowledge, their students may similarly fail to gain a significant appreciation for the subject. Teachers need a high level of content area knowledge to be able to know how best to scaffold the learning experiences for a variety of students with varying understandings and ability levels (Stipek et al., 2001).

The more problem-solving strategies a teacher knows, the greater the likelihood they will recognize and be able to guide student thinking toward understanding. If teachers are not continually seeking growth in their professional knowledge while learning from their students, they will miss opportunities to maximize student understanding of mathematics.

Teachers' beliefs about students impact their views of which students can learn math and how it should be taught. Research has found that some teachers believe that high achievers should be exposed to complex, advanced math instruction, while lower achieving students should not. Zohar et al. (2001) found that 45% of the math teachers in their study believed that low-achieving students should not be exposed to higher-order math. At the same time, 70% of these teachers believed that challenging, conceptual mathematics helped develop students' reasoning skills and induced curiosity while almost half agreed that traditional textbook, lecture-type learning was "boring compared to thinking-based learning" (Zohar et al., 2001, p.477). This seems to be a contradiction. Although these teachers believed that complex, inquiry-driven math is more engaging, they simultaneously felt that low-achieving students should be denied this engaging instruction in exchange for simpler, less conceptual, rote lecture, memorization and procedural-type instruction. This is exactly the kind of instruction from which these teachers agree students will get less benefit and enjoyment, and therefore, less learning. I believe a detrimental cycle is created whereby low-achieving students are subjected to what many would consider boring math and therefore, have fewer incentives to progress. At the same time, high-achieving students are given access to exciting, challenging, conceptual mathematics, which engage their interest. As a result, the mathematically strong get stronger while the weak get weaker.

Lack of faith in all students' ability to learn math is evident when teachers and institutions enact practices like ability grouping or tracking. With tracking, high achieving students are grouped into classes with other high achieving students, while lower achieving students are grouped together in lower-level remedial classes. A pervading belief has been that higher achieving, faster students will learn better when grouped with other advanced students, while lower achieving, slower students will benefit from separation into special groups where simple math can be administered in ways that do not overly challenge them. Educators are often also concerned that slower students prevent the faster students from learning as much as they could. The problem with this theory is that research shows that students benefit when math classrooms are detracked and they learn conceptually in classrooms of students with a range of abilities (Boaler, 2002; Burris, Heubert, & Levin, 2006). Research shows that in these mixed-ability groups, both the high achieving and the low achieving students learn more (Stevens & Slavin, 1995). Remarkably, students' mathematical outcomes hinge not on their initial mathematical ability, but on what is expected of them. Burris et al.(2006) had the opportunity to study a high-school that detracked their math classes with the result that all students, especially low-achieving students, succeeded at much higher rates when placed in rigorous classes with high expectations. When teachers believe in student ability, provide rigorous learning opportunities and positive support, all students can succeed at challenging mathematics.

Although Zohar et al.'s (2001) study of how teachers' beliefs contributed to their segregation of students by ability level was conducted in Israel, their results are supported by similar research findings and observations from practicing US and UK teachers (Boaler, 2002; Featherstone et al., 2011; Van de Walle et al., 2010). These contradictory beliefs about student abilities lead not just to tracking students into homogenous groups, but ultimately to the withholding of beneficial mathematical challenges from a large percentage of students incorrectly considered less than capable. Mathematically low-achieving students are statistically overrepresented currently by female students, linguistically, racially and culturally diverse students, and students with low socioeconomic status (Featherstone et al., 2011; Van de Walle et al., 2010). Therefore, math begins to emerge not just a simple question of who is good at it and who is not, but as an issue of academic access closely linked to social justice.

Culturally Relevant Teaching

Given the significant impact of teachers' beliefs on shaping what happens in the classroom, it becomes important to reflect on a fundamental aspect of belief: the culture of both the teacher and the students. When teaching math to a group of students who may not share many cultural commonalities or communication styles with their teacher, being culturally aware becomes a very important teaching skill. Students who are racially, culturally, or linguistically diverse, or disabled, often lose out during instruction because of failures to connect to and be understood effectively by US teachers who are overwhelmingly White, highly educated, middle-class, and female (Michaels, 1981; Van de Walle et al., 2010). According to Delpit (1988), middle class teachers often use passive, covert communication styles versus direct, overt communication styles. For example, White, middle class teachers often frame directives as questions, such as “Is this where the scissors go?” or “Is this what we are supposed to be doing right now?” These passive, covert directives can be particularly hard for culturally and linguistically diverse students, as well as students of lower socioeconomic status, to interpret, causing misperceptions and problems in the classroom (Delpit, 1988).

In addition, teachers often find that connecting and communicating with children of differing races and ethnic backgrounds can be more challenging than connecting and communicating with students of their own race and ethnic background (Michaels, 1981). This reduced level of communication and understanding can lead teachers to mistakenly believe that students of other backgrounds may have a lower grasp of the materials. I believe that the mathematics classroom is a prime place for this kind of miscommunication to happen, so implementing teaching practices that tap into alternative ways of thinking and communicating across cultural boundaries is important to me. By providing more opportunities for dialogue and understanding, along with highlighting and embracing diverse solutions and views of problems, I believe that appreciation of diverse student perspectives can be surfaced and highlighted to ensure students from historically minoritized populations are given access to complex, challenging math. Additionally, I believe acknowledging and assigning competence to diverse views of mathematics solutions can increase all students understanding.

Status

In the US, mainstream culture means dominant culture, so students who conform to cultural norms of power tend to have higher status than those from minoritized populations. Being a White, upper class, male generally affords higher status than being a Black, working class, female (Delpit, 1988; Cohen, 1994). According to Featherstone et al. (2011), status in the classroom is a major factor in student learning outcomes. There is no status-free human environment because humans are hierarchical by nature and status forms in every group (Howard, 2013). Classrooms are no exception. Students who are identified as high-status typically get more of the instructor's academic attention in traditional teacher-centered mathematics classrooms (Cohen & Lotan, 1995) and this tends to reinforce their learning and cause them to excel. Low-status students tend to experience less participation in the learning process and this tends to reinforce a self-perpetuating cycle of continually lower status and lower participation (Featherstone et al., 2011; Cohen, 1994).

Status effects can be minimized by teachers who use techniques that ensure low-status students have access to the task and publically highlight students' correct thinking and answers. As the highest status person in the classroom, the teacher's actions and beliefs have a strong influence on students (Cohen & Lotan, 1995, Featherstone et al., 2011). Therefore, it is very important that they use their position to make sure that when lower-status students in the classroom demonstrate understanding and engagement, this fact is publicly called out and their competence is verbally acknowledged to the group. A teacher's assigning of competence to low-status students has to be “public, highly specific, and valid so that the student and other members of the group will find the evaluation believable and understand precisely what was done well” (Cohen & Lotan, 1995, p. 103). This has the effect of raising a low-status student’s sense of efficacy and participation, and this in turn begins a positive feedback loop wherein that student continues to increase participation and desire to demonstrate skills, leading to higher achievement (Featherstone et al., 2011). In an experiment with second graders and sixth graders, Cohen & Lotan (1995) showed that use of status treatments such as identifying and reinforcing low-status students in a focused way, produced a demonstrable improvement in the participation rate of these previously non-participatory students, while not having any detrimental effect on the participation of previously high-status students.

Although Cohen & Lotan (1995) present convincing findings, I do have critiques of their research. Eleven of the thirteen classrooms contained solely minority students while in the other two classrooms where White students were present were of overwhelmingly low socioeconomic status. This makes me wonder about what the internalized status interactions of the students were in general, in relation to majority culture, not just in this classroom, and whether or not these results were shaped by cultural differences. Would these results hold up if you enacted this study in a classroom where there were students of racial, linguistic, ethnic and other minority status were heterogeneously mixed within a population of middle or upper class White students? Since eleven of the classrooms were very homogeneous racial groups — two classrooms of Southeast Asians, nine classrooms of Hispanic students — I wonder if their cultures may have shaped the results? Studies on field dependence-independence have shown that there can be significant cultural bias when it comes to students' proclivities for interaction as a group, whether they identify as more intrinsically or extrinsically motivated, and whether they respond more positively to internal or external loci of control (Ramirez & Castaneda, 1974; Bolocofsky, 1980; Thompson, Watt, & Liukkonen, 2014).

As for the transferability of this study, I believe it is difficult to assess due to the author's reliance on relatively quantitative data (surveys, coding number of talk interactions, etc.). Looking at numbers and types of interactions, along with status rankings achieved numerically can help paint a valuable picture of what's going on in a classroom. However, I feel that the authors could have assisted the depth of their findings by delving deeper into the students' and teachers' perceptions of what was happening. Student interviews, teacher interviews, and a deeper investigation of the cultures of the participants would have helped buttress the authors' claims with greater substantiating detail. This deeper level of detail would also help a reader of the survey decide how similar or different this setting and participants were to their own experience. This would allow a reader to decide more clearly how transferable this study's findings might be to another setting.

Additionally, I question the method researchers used for assigning status. Their surveys asked students to point out which of their classmates were "best at math and science" and which were their "best friends". They then assigned each student a rank based on how their peers had ranked them academically and socially and called the aggregate of these data a student's status. I believe students could have assigned social status based on other attributes besides math and science credibility or number of friends. These students with other types of high status might exert control on classroom discourse even though they are not good at math or best friends with a large number of peers. I do not believe these issues invalidate the findings, but they do introduce questions about reproducibility of results among groups with homogeneous but different attributes, as well as among heterogeneous groups. It would be useful to find a way to deepen and put a finer point on what different types of status in this setting mean, what status the authors were tapping into with their measurement, and the potential effects of other, unaccounted types of status.

In Cohen & Lotan's favor, years of teaching experience by Featherstone et al. (2011) also emphasized reinforcement and targeted assignment of competence as ways to mitigate status. They instruct that assigning competence to low-status students is an effective way to minimize status effects. As experienced by Featherstone et al. (2011), increasing low-status students' access to the task raises their participation levels, mitigates negative status effects, and positively affects learning and ongoing achievement.

Group formation and facilitation by the teacher also has the ability to minimize status effects. For example, if students are allowed to form their own groups, they will typically discriminate against each other on the basis of status and this fact is often unseen or ignored by teachers, especially in elementary school classrooms (Featherstone et al., 2011). According to Featherstone et al. (2011), the teacher can structurally minimize status by assigning students to groups randomly and to assign group members specific roles such as facilitator, resource monitor, reporter and captain. Each of these roles has a critical function that requires each to participate fully in order for group success. This has the effect of putting low-status students in positions of importance where other students become dependent on and vested in the successful participation of those lower status students.

Again, it is important to remember that the teacher is the highest status person in a classroom, and students are most likely to model toward each other the types of scaffolding and support interactions they experience from the teacher. In short, students treat each other the way the teacher treats students, so positive modeling is very important (Gnadinger, 2007). If the teacher undertakes the minimization of status effects and the purposeful eliciting of the full range of student perspectives in a room for the benefit of all learners, their belief that everyone can learn math will transfer to their students.

Self-Theories

Many students struggle in math because they don't believe they can successfully learn and apply complex mathematics. These students have negative theories about their own abilities to succeed through persistence and effort (Dweck, 2000). As students get older, they tend to progressively believe that their abilities are a fixed part of who they are, their inherent *traits*, versus theorizing that their abilities are based on their *actions* and therefore more open to change and improvement (Benenson & Dweck, 1986).

According to Dweck (2000), there are two main self-theories that students use to explain their abilities: the *entity theory* of intelligence and the *incremental theory* of intelligence which are contrasted in Table 1.2.

Table 1.2

Entity Versus Incremental Views of Intelligence

Entity View	**Incremental View**
Believes intelligence is fixed or stable	Believes intelligence is malleable, fluid and changeable
High desire to prove self to others	Derives satisfaction from process of learning
Sees challenges as threats to image or self	Sees challenges as opportunities to get better
Wants to be seen as 'smart' and avoid looking unintelligent	Doesn't focus on what outcome will say about them, but what they can attain by taking part
May give up easily if challenged	Desires to master challenges
May purposely avoid challenges in order to avoid failure OR may choose overly difficult tasks so they have excuse to fail	More likely to consider alternative ways to approach challenges; increases effort when challenged
Connects performance with intelligence; believes failure represents a lack of intelligence	Connects performance with effort;believes failure represents a lack of effort or practice
Believes that having to try hard implies a lack of specific intelligence	Believes that increased effort will increase their intelligence

Note. Adapted from Dweck, 2000

Entity theory holds that an individual's intelligence is 'fixed', that they have latent, finite stock of natural talent. An entity theorist, believes individuals are either naturally good at math, or that math is just not something with which they are compatible. On the other hand, an incremental theorist believes that an individual's intelligence is flexible and malleable and can change. Incremental theorists believe that practice makes perfect, that it is acceptable to make mistakes, and that by persistence and effort, they can improve. When entity theorists fail, they tend to believe that they are just bad at, or naturally unsuited to understanding mathematics. This becomes a reinforcing cycle where they expend less or no effort because they are certain of failure. By continually limiting their effort, they do not improve, thus validating their continued failure. On the other hand, when incremental theorists fail, they take the setbacks as part of the learning process, not as personal condemnation (Dweck, 2000). Therefore, it is incumbent upon teachers to identify and encourage practices and thought processes that move students to become incremental theorists in their thinking in order to achieve optimal math learning outcomes.

Intervention by teachers can change students' self-theories from entity to incremental. These practices can have long-lasting impacts on observed student achievement (Blackwell, Trzesniewski, & Dweck, 2007). Intervention is important because children's self-theories matter a great deal in individual learning outcomes (Heyman & Dweck, 1998). Because teachers are the most powerful role model in the classroom, their practice and views of self-theories can dramatically shape and change students' views of themselves and each other (Featherstone et al., 2011; Zohar et al., 2001; Stipek et al., 2001). By actively shaping discussion, and presenting examples and statements that support an incremental view of intelligence, students' views can be directed away from entity theory (Heyman & Dweck, 1998). This direction away from entity to incremental self-theories has been shown to have a positive educational outcome, not only for a particular class, or subject, but across all areas of learning.

Blackwell et al.(2007) longitudinally studied hundreds of New York City seventh and eighth graders in cohorts to determine the effect of introducing groups of students to more incremental self-theories. Their blinded results showed that imparting incremental-type self-theories to students has a lasting impact on their educational outcomes, both in their current classroom as well as into their future classrooms. Students in the experiment group received a non-math lecture that had purposefully incremental-theory instruction embedded in the curriculum while students in the control group received similar academic content without the embedded incremental-theory treatment. The results were enlightening. When researchers checked to see how these students were performing in their math classes, they found that the math teachers were seeing improvement in motivation and/or performance by many students in class. Tellingly, seventy-five percent of the students seen as improving in performance or motivation were from the experimental group that had received the incremental theory treatment. Only twenty-five percent of those showing improvement were from the control group. During the experiment, neither the regular classroom math teachers nor the students knew who was receiving the experimental treatment versus the control. Ultimately, the math students who received the embedded incremental theory training had slightly improved math grades over the study period while the group without incremental theory training had steady math grade declines over the study period. The authors noted,

> Nearly 2 years later, students who endorsed a strong incremental theory of intelligence at the beginning of junior high school were outperforming those who held more of an entity theory in the key subject of mathematics, controlling for prior achievement. Students with an incremental orientation had more positive motivational beliefs, which in turn were related to increasing grades (Blackwell et al., 2007, p.253).

This study shows that when students are empowered with even a small dose of incremental self-theories, they take that empowerment with them as they move into their math classes. It shows that they also take it not only to their next class, but into the future as they move into the world, into social and professional contexts. Education for understanding and student empowerment truly has the potential to change the way people think, and therefore their lives. This ability to change one's views of self as able to be academically successful is important if we look at education as a gateway to improved future economic outcomes, especially for traditionally marginalized and low socioeconomic status students. For these students, in particular, moving ahead in the education system and possibly being the first person in their family to go to college, can be life changing not only for them, but for their families as well as their communities.

Looking For A Solution

The problems with traditional math instruction and known solutions described in this paper call for classroom practices that show students their teacher is passionate about math, believes all students can learn math, and that their culture is an important aspect of engagement. These problems call for the teaching of incremental self-theories holding knowledge of math as a continuum — no matter what level we start at, we can all move forward with practice and persistence. The problems posed call for the acknowledgement and minimization of status effects so that students from many skill levels, cultures and perspectives can contribute what they know for the benefit of the whole group. Importantly, these things must be accomplished in a learning community that is dialogic, where teachers and peers press each other for understanding, and process successes and mistakes together as learning opportunities. They require an environment that values understanding more than speed, collaboration over competition, and listening to every voice, not just those of typically high achievers with high status.

The number talk format presents a practice that embodies all of these potential solutions in one activity. Number talks are, simply put, interactive, engaging, brief, group activities that involve a uniquely intense discussion or interaction around mathematics. According to Parrish (2010), number talks are typically implemented at the beginning of a math class, occur several times a week, and take ten to fifteen minutes to complete. Number talks generally take up a specific aspect of mathematics as a focus and unfold as a student-centered group interaction where students are guided toward specific understandings. Parrish (2010) states that number talks benefit students by providing them the opportunity to:

1. Clarify their own thinking
2. Consider and test other strategies to see if they are mathematically logical
3. Investigate and apply mathematical relationships
4. Build a repertoire of efficient strategies
5. Make decisions about choosing efficient strategies for specific problems (Parrish, 2010, p. 11)

Number talks are a structural as well as a social process. They can build community as a special event with special rules and norms. Students can be encouraged to find and share multiple strategies, engage in dialogue with both peers and the teacher, and be pressed to describe and defend their thinking.

Number talks are a tool to make math more real, more accessible and more understandable for students. Number talks are centered in student-centered instructional practices and empower students as co-teachers, co-creators, and co-evaluators of knowledge. Number talks also encourage dialogue and community interaction, which empowers students in and beyond class.

Number talks provide a unique vehicle for addressing many problems students have with learning math. As a teacher, my implementation of number talks is an expression of my belief that everyone can learn math, everyone can improve their math skills, and that as a 'math talk' community (Hufferd-Ackles et al., 2004), we can all learn from each other. Learning math in this context also means empowering students to think critically and to work together with their peers. These skills could be invaluable in future decision making processes and problem solving. Proficiency at complex mathematics means being able to critically read the world through mathematics (Gutstein, 2005). It means students will be more informed future citizens, capable of discerning fact from fiction more readily, capable of being socially, politically and economically more empowered.

Underserved students are typically overrepresented in remedial, tracked, low-achieving math populations. If number talks have the power to affect these students' status and self-theories in the elementary classroom, then they have the power to alter students' academic trajectories in middle and high school and beyond. Society's increasing complexity and reliance on technology is only going to raise the necessity for people with mathematical understanding. Ensuring that all students, especially marginalized populations, have access to robust mathematical understanding means laying the groundwork for a more equitable future for all of us.

Given the research presented in my literature review, status and self-theories appear to be two central components to students' ability to access and learn mathematics. At the same time, number talks appeared to provide a range of actions that might produce positive changes in status and self-theories. Since little research has been published on the effectiveness of number talks in addressing these two important parameters, my research question became: How does the use of number talks in a fourth grade math classroom impact students' status and self-theories?

CHAPTER 2 — METHODS

Setting and Participants

Ferryhill Elementary[1] is located in a suburban area of Washington State's Puget Sound region, and serves students from a wide range of racial, cultural, and socio-economic backgrounds. Racially, the student breakdown is roughly 1% Native American, 9% Asian, 3% Native Hawaiian / Other Pacific Islander, 12% Asian / Other Pacific Islander, 6% African American, 14% Hispanic / Latino and 55% White. About 13% of the students identify with two or more races. Additionally, about 23% receive free or reduced lunch, 11% are in special education, 1% are Transitional Bilingual, and 2% are Section 504. Students are evenly split between female (50%) and male (50%) (Office of Superintendent of Public Instruction, 2014).

During my research project, Ferryhill was home to roughly 400 students and only had fourth and fifth grades on site. A majority of students were bused in from a wide area after completing K-3 at other district schools. A large military base was adjacent to the community and approximately half the students at the school came from active-duty military families.

The instructional setting could be described as traditional. Math classes were majority teacher-centered with occasional student-centered instruction such as cooperative small-group tasks like solving complicated multi-step problems. My assumption was that the feeder schools in the district (K-3) also follow this pattern, so students arrived at Ferryhill with a teacher-centered perspective on instruction. The

[1] School, student, and teacher's names have been changed to ensure anonymity.

school’s fourth grade average standardized math scores from the state assessment were just above the state average for fourth grade (63% state average; 64.5% Ferryhill). A small number of students were tracked out of regular math class a portion of the time for intervention. This included both low-achieving students receiving remedial training, as well as high achieving students receiving advanced curriculum. When in the classroom, low-achieving students were often given specialized assignments to work on while the bulk of the students pursued grade-level objectives. High-achieving students worked with peers on grade level tasks unless out of the room for advanced enrichment called High Cap (short for Highly Capable).

The students in my classroom at Ferryhill Elementary were a diverse slice of American fourth graders whose demographics closely resembled that of the larger school. I was fortunate to work in a co-teaching environment where I was responsible for math and science instruction, while my co-teacher taught English Language Arts and social studies. This allowed me to see a larger number of students for my math lessons and provided multiple views of the same techniques applied under different group dynamics. This structure allowed me more practice at delivering number talks and allowed me to get a wider range of student perspectives. This in turn helped me draw conclusions about the efficacy of number talks at affecting status and self-theories of my students.

Classroom Environment

The classroom itself was arranged so students sat clustered in groups of four facing each other. This provided easy elbow-partners and small groups while allowing easy circulation of the traffic around and through the room. During number talks, students moved to a large open area at the front of the room adjacent to a large white board, which was often used during the number talk process by the teacher and students.

During the study period, the students engaged in approximately twenty number talks (roughly two per week). Number talks were delivered primarily by myself, but some were delivered by my mentor teacher while I observed. Additionally, this was a co-teaching situation for student teaching and so for a period of a couple of weeks, I switched classrooms to teach ELA and social studies while another student teacher took on math and science. During this switch, the students still received number talks, just from teachers other than myself. This partial sharing of number talk delivery provided an additional opportunity to debrief with fellow teachers about the process, while reinforcing the core message to the students that a diversity of approaches to the same task was a strength to be shared and that in general, there are many correct ways to approach something. I continually reinforced the idea that the more ways we have to solve a problem, the more likely we are of arriving at a correct solution, and that knowledge of several methods meant we could always check our work a different way to ensure accuracy.

How We Practiced Number Talks

As practiced in my classroom, number talks were student-centered mathematical discussions that used mental math to solve problems in a group-setting where discourse and differentiated thinking strategies were encouraged. Number talks required students to move from their desks to a designated area of the room where they sat on the floor next to a white-board for presenting problems and recording student thinking. I would present a problem to the group, and then elicit responses from students. Since number talks are typically conducted mentally, students did not bring pencils or paper to the discussion, instead focusing on mental strategies. I would often have a student record his or her own strategy on the board. Typically, I would ask several students to record their strategies, one at a time, during any number talk. At this time, the rest of the class would work on strategizing in their heads and agreeing, or disagreeing with the work being presented. When disagreements over answers to a problem arose, we would record all student answers on the board before talking through each until the entire class agreed on a single one as correct.

To get a better picture of what a typical number talk in my classroom looked like, I provide the following excerpt transcribed from a video taken about halfway through my study:

> **Teacher:** [walking over to an open area of the room adjacent a whiteboard] Ok. Everybody come over here…[children get up and move over to the number talk area and sit down in a loosely clustered semi-circle]
>
> **Teacher**: OK, everyone should make sure they get a seat where they can see what's going to be written on the board and a place where we can hear your voice. Nobody should have anything to write on.
>
> **Teacher:** We kind of did this a little bit yesterday [writing problem on board]. We all remember how we show we have an answer right [teacher demonstrates "quiet thumb" and students switch raised hands to "quiet thumbs"[2]].
>
> **Teacher:** Ok, so, Connie?

[2] "Quiet thumbs" are placed on chest to show student has a strategy instead of waving hands in the air. This minimizes distraction and allows other students to continue to think without the added pressure of seeing other people already have a solution to the problem.

Connie: 28

Teacher: Do people agree? [Teacher demonstrates "agree" sign[3]]

Class: [doing agree sign… a couple of students blurt "yes"]

Teacher: [Writes another problem on board. Students put up "quiet thumbs".]

Teacher: Hara

Hara: 280 [Many students give "agree" sign.]

Teacher: Ok, this is where the fun starts.

Class: [Chorus of "uhuh" "yeah"]

Teacher: Who can tell us ***why*** 4 x 70 equals 280?... Annie?

Annie: because once you start with 28, you're just moving the two to another place value and the eight to the place value next to the two and then just … and then putting a zero [at the end] because we don't just have another pla- … we don't have another number for the uh… we're adding ten each time we move a place value.

Teacher: Were *adding* ten?

Annie: I mean times ten

Teacher: So it's getting how much bigger?

Annie: Ten times

Teacher: So, what I heard Annie just say was that if we had a twenty-eight in this problem. And then we took the two that was in the tens column and we moved it into the hundreds column. And we took the eight that was in the ones column and we moved it into the tens column, right? And then we had to put a zero there [at end] to hold the place value, right? and so, so, every time a digit hops over one place value to the left, how much bigger did it get?

Carlos: Ten times

Teacher: It got ten times bigger? People agree with that [demonstrating "agree" sign]?

Class: [Majority showing "agree" sign.]

[3] "Agree" sign is the same as ASL hand sign for "I am thinking what you are thinking". We use hand signals when showing we agree with each other, we disagree with each other, and when we are still thinking. This allows students to express their thoughts and opinions nonverbally which minimizes distraction while maximizing interaction.

Evident in this exchange, there are several practices that distinguished our number talks from traditional mathematical classroom practices. In our number talks, students used response practices that minimized their disturbance of other's thinking. This took the form of "quiet thumbs" instead of arm waving or blurting out, and showing agreement and disagreement with peers by using hand signals from American Sign Language.

Our number talks presented me with a variety of opportunities to call on students and highlight their thinking strategies. This allowed opportunities to focus on novel, efficient, or otherwise remarkable strategies from low status students who might not typically have a chance to distinguish themselves in a more traditional math activity. This chance to address status in the classroom gave students with lower status opportunities to exhibit valuable thinking and strategies and me the opportunity to assign them competence.

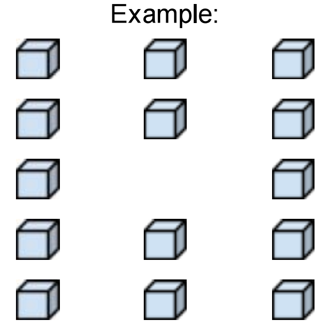
I practiced number talks that provided multiple informational access points for students, such as verbalizing and visualizing problems, and I ensured we sought out a variety of means for solving the same problem. Because emphasis was placed on explaining mathematical thinking, not just on stating the correct answer, students were challenged to deeply process the math. They did this not only by formulating explanations of their own thinking, but also by listening to other's thinking. A student who initially had an incorrect answer often expanded other students' understandings as she talked through her own thinking with feedback from peers. As I recorded strategies on the board during our discussions, students had the benefit of both seeing and hearing problems solved step by step. This helped me reinforce the idea that individual mathematical understanding lies on a continuum. Every time we thought about, talked about, or practiced math, we had an opportunity to push our understanding a little further along the continuum.

During my study, I used several common types of number talks, namely *strings*, *choral counts*, and *quick images*. Table 2.1 shows an explanation and example problem for each of these types of number talks. When presented, number talks were given as a mini-lesson at the beginning of math class, and always related to the content or concepts we were studying in our larger lesson.

Table 2.1

Types and Examples of Number Talks Used During Study

<table>
<tr><th>Strings</th><th>Choral Counts</th><th>Quick Images</th></tr>
<tr><td>Strings support students in utilizing a specific computational strategy with a series of related problems the teacher presents, one at a time, to the students.</td><td>A repeating pattern (such as n+3) is introduced to the students, usually in a grid format. Students calling out in rhythmic unison provide answers to the number pattern as the teacher records them.</td><td>Students are shown a flash of an image that contains a number of shapes. The image is then hidden and students are asked to say how many shapes there were. Different visual thinking strategies are highlighted.</td></tr>
<tr><td>Example:

100 - 99
100 - 89
100 - 79
100 - 49
100 - 29
100 - 9</td><td>Example: n+3
<table>
<tr><td>1</td><td>16</td><td>___</td></tr>
<tr><td>4</td><td>___</td><td>___</td></tr>
<tr><td>_7_</td><td>___</td><td>___</td></tr>
<tr><td>___</td><td>___</td><td>___</td></tr>
<tr><td>___</td><td>28</td><td>___</td></tr>
</table></td><td>Example:
</td></tr>
</table>

Data Collection And Analysis

Through this action research project, I sought to determine how the implementation of regular number talks affect patterns of student status and self-theories in the math classroom. I believed that status and self-theories were interrelated but not identical and that changing one could affect the other. Therefore, I attempted to track both of these metrics in the students and make correlations with delivery of number talk instruction and other available indicators such as assessment data and student feedback on the process.

Status and self-theories are deeply personal ideas held by individual students, both about themselves and about their peers. I believed the best way to get to these data was through the use of surveys, interviews, and the video recording of number talk interactions. I also simultaneously maintained a research journal while attempting to draw correlations between on-going academic performance and student status and self-theories. Merten’s (2010) calls this use of both qualitative and quantitative data a mixed methods approach, and I chose it believing having both quantitative and qualitative data would help give me deeper, more reliable results.

My research sought to answer whether regular implementation of number talks could mitigate or improve effects of status or if implementation could move students’ self-theories from entity views toward incremental views. I believed that the dynamics and structure of the number talks would create conditions for this to happen, namely, by exposing students to multiple strategies, highlighting the thinking of other students, making math more fun and meaningful, and creating a community atmosphere where we continually emphasized our ability to grow and see new things. To this end, I collected data that captured changes in status and self-theories, and data that linked these changes to the practice of number talks. In the following sections on my data sources, I will discuss what I collected, when I collected it, what I was trying to capture, and how I analyzed it for findings.

Surveys

Students were given multiple surveys during the study period (see Table 2.2). I used survey data to look for conclusions to my research question on the effect of number talks. Survey data provided a direct window to students' thinking and feelings about themselves, their peers, and about number talks.

Table 2.2

Survey Implementation Overview

Survey*	Conducted at Beginning (Week 01)	Conducted at Middle (Week05)	Conducted at End (Week 10)	Single Use
Math Status Survey	X	X	X	
Self-theories Survey	X	X	X	
Math Smartness	X	X	X	
Number Talk Survey 1				X (Week 02)
Number Talk Survey 2				X (Week 10)

* Detailed survey forms and results can be found in *Appendix A*

Math status surveys. This survey (see Appendix A1) sought to capture students' status ranking in the classroom. I adapted it from a common sociogram model created by Jacob Moreno (1934). While typical sociograms ask students to list two or three peers they want to play with, or want to work on a task with, my adapted survey consisted of asking students to list all of the peers in their class they felt were "smart at math". Responses ranged from students only listing themselves, to students listing all twenty-four students in their class. I assigned individual math status based on the number of times a student was identified as "smart at math" on a survey. If sixteen out of twenty-four students said Pedro was smart at math, Pedro's math status score was 16/24 or 0.67. The more peers select an individual as "smart at math", the closer their math status was to 1.0, and the higher their math status as perceived by their peers. With repeated administration of this survey over time, trends emerged. I coded (Auerbach & Silverstein, 2003) this data by looking at the pattern of students gaining or losing status. I calculated individual gains and losses of status between each survey iteration and I tallied these gains and losses together for status changes by individuals over the length of the study. With 48 students, the individual data became overwhelming, so I used individual status measures to calculate an overall status for each class for each survey. These class status ranks were then used to calculate percentage changes over the course of the study.

Self-theory surveys. This survey (see Appendix A3) consisted of a series of ten statements that gauged students' self-theory (entity versus incremental) based on an instrument in Carol Dweck's (2000) book *Self-theories*. A Likert scale showed student responses on a continuum between entity and incremental theories. This purpose of this survey was to allow me to allowed me to determine a beginning point and ending point for each student's self-theory by assigning them a scale rating. With repeated administration of this survey during my study, I captured shifts occurring for individual students in their self-theory identification. I coded these individual student changes by direction shift and amount, and aggregated them together to express a net change for each class. I correlated observed individual shifts and aggregate class data with other surveys and observations as my findings emerged.

Math smartness surveys. This survey (see Appendix A5) consisted of a list of 23 different math "smartnesses" — that is, different characteristics that are beneficial for math success. Students were asked each time they were given the survey to circle the smartnesses they felt they were currently good at. At the bottom, they were given a space to identify up to three characteristics they felt they wanted to improve in the future. My use of this survey sought to determine beginning and ending feelings students had toward themselves about their math abilities. I wanted to see if practicing number talks changed this over time, and with repeated administration of this survey, I was able to code instances of individuals changing their self-identification of math abilities. I then aggregated individual changes to see if patterns of group-identified math smartnesses were increasing or decreasing.

Number talk surveys. During the study period, I also conducted two surveys specific to student experience of number talks. In *Number Talk Survey 1* — a simple two questions administered near the beginning of the study — I asked them what they liked and didn’t like so far about number talks. I coded their responses by looking to see patterns that emerged and how they fit into my findings. At the conclusion of my study, I provided students a more robust *Number Talk Survey 2* (see Appendix A7) that used ten statements with a Likert scale to assess their personal experience with number talks. This survey was coded by looking for emerging patterns in individual and aggregate student responses. These emerging patterns helped lead to my two main findings regarding changes to status and self-theories being affected by number talks.

Interviews

At the conclusion of my study, I conducted interviews with eight students to deepen my understanding of the effects of number talks on their status and self-theories. The information from a selection of individuals served to paint a much more detailed picture than the survey data alone, whereas the surveys allowed me to reach many more students than I could have with interviews. I interviewed students that varied in status, mathematical ability, and self-theory identification. These students were asked to describe what effects if any, the number talks had on their perceptions of self-theory and status (see *Student Interview Questions*, Appendix B). These interviews were transcribed and coded to look for emerging patterns that eventually became findings.

Video Recording

A portion of number talks were video recorded. A typical number talk was generally fifteen minutes long. I watched recorded sessions and took reflective notes on my practice and general observations. I also chose portions of video recordings to transcribe and code, looking for evidence of how number talks related to patterns I saw emerging in other data sets related to students' status and self-theories.

Research Journal

I used my research journal for reflecting on number talks as well as for recording other ideas and observations I had during the research process. My reflections served as a guide to finding emerging patterns in the data as well as pointing out which areas of data held more relevant ideas and clues. When it was time to code and analyze my data, my notes reminded me of some of the larger issues that piqued my curiosity and steered me towards more specific answers to the effect of number talks on self-theories or status.

Limits Of Conclusions

Attempting to understand and quantify how people think about themselves and others is a challenging task under any circumstance. However, I believe I have been able to draw some specific conclusions regarding self-theories and status from this process. Through quantitative surveys, qualitative student interviews, video reviews, tracking of assessment data and by practitioner self-reflection, I believe I have been able to collect data that allowed me to postulate on the efficacy of number talks in affecting status and self-theories, as well as addressing number talk effectiveness at lowering the other barriers to mathematical instruction outlined in this paper. I have also gained additional insight into the implementation of the number talk process by reflecting on my own practice.

It is important to note that this project only applies to a small number of participants in a particular setting. This study has been extremely helpful in guiding my continuing practice, and I hope that the results may be useful to other teachers attempting to determine the value of implementing number talks in their own classrooms. Others reviewing this project should read it thoroughly to determine its applicability to their own context and take my findings accordingly. Again, the phenomenon of number talks is relatively new and relatively unquantified as to measurable benefits, so there were no other findings against which my research could be compared. I hope that in time more work is done that allows me to come back to my findings here and analyze them in a broader light.

It is also important to note that as a student teacher during this project, I was operating under some strong limitations. I did not have the experience level of either a professional teacher or a seasoned researcher, therefore, my conclusions bear a good deal of scrutiny for simple mistakes and biases. As a sole practitioner and researcher on this project, I have likely been subject to blind-spots, errors of judgment, logistical shortcomings and other mistakes. Although I worked with a mentor teacher and other student teachers to add insights to my process, any obvious biases, mistakes, etc. are my own.

Quality Indicators

It is important to note that a large part of the data for this action research project was qualitative in nature and represented my attempt to gauge the effectiveness of using number talks to address student's self-theories and status in an elementary math classroom. Definitive, clear cut answers were not possible, and not my goal. My intention was to see if I could deepen my understanding of the use of number talks and their impact on students, and I feel I succeeded on this point.

Credibility

In qualitative research, credibility revolves around putting forth findings that would be familiar and believable to the participants in the research (Mertens, 2010), in this case, students and teachers engaging in the number talk process. Although credibility is a tricky thing, I attempted to address it structurally, by making student generated data the nucleus of my findings. I collected a large, ongoing amount of survey data straight from questions posed to students. I attempted to deepen this survey data with a selection of student interviews to add voices to the numbers. Additionally, I reviewed hours of interactions of the study participants on video in order to gain a better understanding of the survey and interview data. To this end, I feel that although limited in scope, the findings I have highlighted in this study are true to the experience of myself and my students, and accurately represent the thoughts and feelings of the participants about themselves, each other, and number talks during the study period.

Transferability

The transferability of my research would refer to the degree it can be generalized or used to explain something happening in a different setting or context, and transferability can be enhanced by the researcher presenting a thorough description of the research context, as well as their own assumptions (Mertens, 2010). This paper attempts to provide both a detailed description of the context this project was carried out in, as well as my biases and assumptions. Additionally, I attempted to address transferability in a way I saw potentially lacking in the study by Cohen & Lotan (1995) critiqued in Chapter 1. Instead of only collecting survey data and looking at the numbers, I went further and interviewed eight of the forty-eight students (one-sixth of them) in order to texture the less personal survey data. Students' verbal responses to these questions added a degree of depth not available with the Likert scales on surveys. Ultimately, it will be up to the reviewer as to the usefulness and applicability of my findings in light of their particular setting or context.

Dependability

Dependability in qualitative research addresses the ever-changing nature of any ongoing research context. If ever there was a context that was ever changing, it is a fourth grade classroom. In addition to general occurrences in students' lives and moods, there were ongoing schedule and curricular changes. Math would be canceled and rescheduled due to a presentation in the library, or a fire drill or other standard disruption would occur. These are all normal events in a school setting. Additionally, we had the added context of a co-teaching, dual-classroom model where two certified teachers shared two groups of students, and then allowed two student teachers to come in and work inside their model, switching not only kids, but classrooms. Because of this, the twenty or so number talks I delivered to students were supplemented with number talks delivered by my mentor teacher, as well as another student-teacher. Ultimately, I feel that the combination of various survey data from five surveys — three of which were ongoing and deepened by student interviews — allowed me to conduct a process that was dependable as far as taking these changes and curve-balls of context into account.

Confirmability

According to Mertens (2010), “confirmability means that the data and their interpretation are not figments of the researcher’s imagination… can be tracked to their source, and the logic that is used to interpret [it] is made explicit” (p. 260). During this project, I collected a large amount of data in the form of surveys, interviews, and recorded interactions. I tried to ensure that the data I collected was presented in this paper in as raw, yet readable a form as possible, along with my reasoning for making these interpretations. In this way, I hope to allow the reader enough information to make up their own mind as to whether they agree or disagree with my findings, and to possibly come up with alternative explanations that could be supported by the data.

CHAPTER 3 — FINDINGS AND IMPLICATIONS

Findings

Due to the large amount of data I collected during the ten-week study period, many interesting themes and patterns arose. At first the data seemed to represent multiple things, but after continued coding, reflection, and analysis, I was able to merge them into two main findings. My first finding was that during the study period, the overall peer-assigned status of my students rose measurably. My second finding was that during the study, students' self-theories shifted away from entity and toward incremental views of themselves. Data supported conclusions that these changes in status and self-theories were related to our classroom practice of number talks. In the following sections, I will outline my two findings in greater detail and show how they are tied to the practice of number talks.

Increasing Academic Status

During the study period, data emerged that supported my finding that overall status for both classes rose. I will present multiple pieces of evidence here that support both a general rise in status, and my claim that this change can be at least partially attributed to number talks. My first evidence that number talks were exposing students to each other's thinking in a way that positively impacted students' status came from *Number Talks Survey 1* near the beginning of my study. When asked to list one thing they liked about our initial number talks, the three top positive conditions students cited were 1) learning about math, 2) sharing multiple strategies or ideas, and 3) interaction with others. It is clear that students felt that number talks were providing them opportunities to learn math in the context of peer interaction where they were being exposed to multiple ideas and strategies. I believe this exposure to each other's thinking was key to observations of changing math status. Also, an important part of this was the fact that I was taking the opportunity to call on and highlight the correct mathematical thinking of otherwise low status students.

A central source of data that supported my finding that math status was undergoing a positive change was the results of my *Math Status Survey* (see Appendix A1 & A2). This survey showed how many peers believed each student in my classes was "smart at math". A rising number signified a rising status. Individual student statuses were averaged together to form a group status for each class. These were calculated for each of the three iterations of the Math Status Survey. Over the course of the three survey distributions, the change in status became apparent.

Table 3.1

Class Average Math Status Survey Results

	Class M1					**Class: M2**			
	Status Survey 01	Status Survey 02	Status Survey 03	% △		Status Survey 01	Status Survey 02	Status Survey 03	% △
Class Avg	.46*	.53	.59	+28%	Class Avg	.38	.59	.59	+55%

*The scores shown for each survey have taken the individual status of each student from the class and aggregated them together for a class average status. As with individual scores, the higher the number, the higher the overall status.

As is evident in these survey results, status underwent a considerable upward shift. The status of both classes was lowest at the time of my initial survey. Both classes then experienced a rise in status by the time of my middle survey, and both classes had gone up even further by the time of my final status survey.

It is important to note why this data source points to number talks as a transformative factor. This survey asked students to assign status to each other around perceived mathematical competence. In a traditional math classroom, instruction is teacher-centered and students have little direct interaction with their peers around content. Instruction becomes more student-centered if students are asked to work together to solve problems, such as with group tasks. Number talks represent a very student-centered practice where students are engaged in dialogue, sharing their thinking and actively listening to the ideas of others. This orientation towards each other's thinking is a necessary component in changing student's perceptions of their peers' mathematical ability, as well as their self-perceptions. It makes sense that as students were exposed more and more to each other's ideas and problem-solving processes, their views of each other as mathematically competent rose as well.

A quote from an interview with student Katya from class M2 provides a good example of how student's exposure to each other's thinking was changing their views of their peers' mathematical competence:

> **Teacher:**
> "Have you ever heard someone who you didn't think was smart at math say something useful or interesting?"
>
> **Katya:**
> "Navin had this one idea that was pretty cool. It kind of made me think "Oh maybe he understands it more than I thought he understood it."

Similarly, when asked if number talks had exposed them to useful strategies from other students, or changed their perception of other students, six out of the eight said they had heard useful or interesting strategies from other students, and were able to name specific strategies or examples they learned from others that changed their thinking.

At the end of the study period, I administered *Number Talk Survey 2* where I asked students questions about their experience of number talks. Specific questions asked if they believed that number talks were responsible for changing their perceptions of their peers math competence. Table 3.2 shows some of their responses.

Table 3.2

Number Talk Effect on Perceptions of Peers

Q. Have number talks changed how math smart you thought some people are?				
Hasn't Changed		Changed A Little		Changed What I thought A Lot
7%	0%	48%	17%	28%
Q. Have you ever learned something new from another student during a number talk?				
Never Learned Something New		Maybe One or Two Things		I Have Learned A Lot Of New Things
2%	2%	48%	12%	36%
Q. Have number talks changed how you feel about other students' math smartness?				
Hasn't Changed How I Feel		Changed It A Little		Has Changed How I Feel A Lot
7%	5%	31%	24%	33%

It is evident in student answers to these questions that number talks were having a positive effect on their perceptions of their peers. 93% said number talks were changing how smart they thought their peers were from a little to a lot. 97% said that they learned at least one new thing from a peer during a number talk. And, 88% said that number talks were changing how they felt about their peers' math smartness. This is direct evidence of the power of number talks to orient students to each other's thinking and to change their perceptions of each other's mathematical competence for the positive.

In reflecting on my practice, I saw that number talks provided me instrumental opportunities for addressing status in the math classroom. I saw that when I effectively facilitated number talks, I was able to reinforce the notion that everyone had something to contribute and that there were often many right ways to get to an answer. I was able to use number talks to reinforce the view that there were many math smartnesses and that each smartness had an important part to play in understanding and solving problems. Our number talks presented students with an interactive problem-solving context to which I was exposing them while also orienting them toward each other's thinking. By hearing and engaging with their peers' thoughts they began to build greater awareness and empathy for each other. I saw that this greater understanding and appreciation of each other that blossomed during the number talk practice led directly to changing and expanding views of mathematical competence, and that had a mitigating effect on status.

Increasing Incremental Self-theories

During the study period, self-theories shifted toward a greater expression of incremental theory and moved away from entity theory. Data that corroborated this movement came from several different surveys, student interviews, and my observations. One source of evidence of this shift came from the *Self-Theory Survey* students took several times during the 10-week study. Table 3.3 shows the averaged class responses to this series of inquiries. On this instrument, a lower number correlated with increased incremental self-theory, while a higher number correlated with increased entity self-theory.

Table 3.3

Class Average Self-theory Survey Results

Class: M1					**Class: M2**				
	Self-Theories Survey 01	Self-Theories Survey 01	Self-Theories Survey 01	% △*		Self-Theories Survey 01	Self-Theories Survey 01	Self-Theories Survey 01	% △
Class Avg	2.66**	2.3	2.23	-16%	Class Avg:	2.31	2.08	1.81	-22%

* △ = Change
**Self-theory rating scale:
1 = lowest possible (absolute incremental self-theory)
4 = highest possible (absolute entity self-theory)

Over the course of the study, class average numbers dropped steadily, which reflects an observable shift away from entity theories and toward incremental theories. During the study, the aggregate average self-theories underwent a roughly 19% change in the direction of incremental self-theories. At the same time, other data from students was showing their feelings of mathematical competence were increasing and that they viewed number talks as a key contributor to their rising math smartnesses.

The *Math Smartness Survey*, given over the course of the project, was designed to track the number of math smartnesses students self-identified as having. The underlying basis of this survey was the concept that there are many skills or “smartnesses” required for the successful completion of mathematics. All students possess some or many of these characteristics, but very few people possess them all. This related directly to our number talks in that the process of mental math accessed and highlighted many of these forms of mathematical intelligence in a way that problems on a worksheet could not. Number talks not only provided students opportunity to access a variety of alternative forms of math smartnesses, but crucially, they allowed students to articulate their mathematical thinking out loud which helped their own mental processing of concepts (Zull, 2002), while simultaneously exposing their peers to new ideas and ways of thinking. Our practice of number talks put students in a position to see their own and their peers intelligence as flexible, multi-faceted, and capable of constant growth.

Table 3.4

Class Average Math Smartness Survey Results

	Class: M1					Class: M2			
	Smartness Survey 01	Smartness Survey 02	Smartness Survey 03	% △*		Smartness Survey 01	Smartness Survey 02	Smartness Survey 03	% △
Class Avg	11.62**	12.41	13.09	+13%	Class Avg	11.43	13.47	14.38	+26%

* △ = Change
** The number shown for each survey is the average number of math smartnesses selected by students for that survey. Over the ten week study period, dual-class aggregate average selected math smartnesses increased by about 20%.

As seen in Table 3.4, students underwent a measured expansion during the study period in the number of math smartnesses they self-identified at possessing — an average increase of 20% when both classes are factored together. When viewed in light of student identification of the part number talks was playing in expanding their sense of their mathematical abilities, this increase in self-efficacy makes perfect sense. During the practice of number talks, students were constantly pushed to expand their thinking. They repeatedly heard other students offer multiple strategies for solving problems, and we constantly talked through incorrect answers as a group so students had a chance to analyze and revise their thinking. This practice showed them regularly that intelligence is not fixed, but can be expanded by continual, critical practice.

When asked on *Number Talk Survey 2* how number talks were affecting their views of their own intelligence, student perceptions of the positive impacts of the practice were clear. Evidence from the survey showed that at the end of the study period that 45% of students felt “very smart” at math and almost 70% stated they were “getting much smarter” at math. 91% identified number talks as helping them “a little bit”, or “a lot” when it came to improving their math smarts. This points significantly in the direction of number talks expanding student views of what both what it means to be smart at math, and how their math intelligence is not fixed, but can be continually expanded.

I believe that number talk’s effectiveness at changing status and self-efficacy is partially related to expanding student views of what math smartness means. Many students came to our classroom thinking of math only in terms of solving number problems written on a piece of paper. My intentional introduction of the concept of many math smartnesses, coupled with seeking out and attempting to highlight these smartnesses during number talks, reinforced the incremental theory that there are many ways to be “math smart” and we can work on accessing and improving all of them. Number talks were a great place to orient students to each other’s ideas and thinking as a group process, and students expressed their appreciation of this early on. I saw that appreciation continued to deepen and grow as we continued the practice.

At the end of the study period, I interviewed eight students to supplement the information I gained from the surveys. When asked whether or not number talks had helped improve her math smartness, Allie said “we're all as a group and everyone can share their feedback on another person's answer, and they can share how they did the problem… a certain way.” This was typical of responses I heard from students about number talks providing opportunities to expand views of their peers’ competence.

Summary of Findings

In summary, during my study period I found through multiple streams of data that average student status underwent a net-positive effect, and that overall, class status went up an average of 42%. I found that student's self-theories shifted in an observable direction toward incremental theories by a class average of 19% in only ten weeks. Data showed that students came to see themselves as possessing higher numbers of math smartnesses, and made the connection that number talks were helping them get smarter at math. I believe this pointedly demonstrates the effectiveness of number talks at positively addressing status and self-theories in the classroom.

Connection Between Literature Review and Study Findings

This action research project took up number talks as an instructional practice that addressed a variety of challenges in students' successful learning of math. I proposed that the practice of number talks would help address some of the problems embedded in traditional, teacher-centered instruction. In this section I want to briefly recap how my action research project findings connect to the research literature, and how I saw number talks, as practiced, addressing the problems outlined in my literature review.

Instructional Practices

Research has shown that student engagement can increase with inquiry-based, interactive, more cognitively demanding instruction. (Stipek et al., 2001; Wood et al., 2006; Kazemi & Stipek, 2001; Morrone et al., 2004), and number talks certainly turned out to be both student-centered, and engaging. Participation can increase when students feel partially in control of the process (Deci, 1995), and learn they more when the process involves not just reciting facts, but reflecting, testing ideas, and putting theories into practice (Zull, 2002). The practice of number talks leveraged all of these activities. Students inquired together, gained multiple perspectives and multiple strategies for solving the same problem. Students used basic facts in new and different ways to find efficient, effective methods for solving complex problems. Students talked about their own ideas and the ideas of others, agreeing, disagreeing, and often revising their thinking. They were engaged by number talks in ways they were not engaged by traditional mathematics instruction, and this heightened level of participation and cognition of math gave students in my classroom a boost. Given the importance of effective pedagogical practices, the fact that number talks contained so many effective ways to leverage learning made them a high-yield investment.

Teacher Beliefs

As the highest status person in the classroom, what I believed about mathematics, and about my students' abilities mattered (Featherstone et al., 2011; Stipek et al., 2001; Zohar et al., 2001). By believing all my students could succeed when exposed to challenging math, and giving them the opportunities to do so, I opened the door for them to push themselves in ways not possible if I'd tracked them into homogeneous ability groups (Boaler, 2002; Burris et al., 2006). Our practice of number talks allowed me to express my love and understanding of math, as well as my belief in all students' abilities. Given the community-centered, dialogic nature of number talks, effective facilitation involved orchestrating an engaging, meaningful, interactive process where students felt understood and came to perceive themselves and their peers as mathematically capable, and competent. During our number talks, students came together to express ideas, defend and revise their thinking, and listen to multiple perspectives about the same problems. In this process, students acted not just as recipients of information, but as co-creators of mathematical knowledge. I learned a lot from them, as they learned from me and from each other.

Culturally Relevant Teaching

In order to effectively facilitate math instruction that is student-centered and strengthened by dialogue and discourse, I had to get to know and understand my students. My students were from many diverse cultural, linguistic, and racial backgrounds, so I had to constantly seek to be aware of my blind-spots to prevent misunderstandings from developing (Michaels, 1981; Delpit, 1988). By implementing number talks, our classroom entered a process much more dependent on nuanced communication between people than simply handing out worksheets and referring to examples in books. Students were tasked with thinking out loud, with discussing multiple strategies, with challenging each other, and with defending their own ideas. This is precisely the kind of activity where understanding of cultural communication patterns of myself as a teacher, and of my students, was most relevant, and most critical.

Status

Status rankings naturally emerge in all groups, and are based on multiple factors including task-specific skills (Cohen, 1994; Howard, 2013). In typical classroom environments, students with higher status end up gaining more teacher attention, more access to the learning materials, and ultimately, higher achievement (Cohen, 1994; Featherstone et al., 2011). In our classroom, the practice of number talks showed that it is possible to treat status in order to minimize negative effects and maximize all students' access to the learning (Cohen, 1994; Cohen & Lotan, 1995; Featherstone et al., 2011). Before undertaking this project, I posited that number talks were a practice that, by their social, interactive, and teacher-mediated nature, would afford many opportunities to address status effects. My practice and data collection supported this claim, and provided me with the additional, unintended insight that status - how students perceive themselves and others as competent - is not a zero sum game. It is possible for everyone's status to go up without winners and losers. By practicing number talks, students conducted a process that exposed them to each other's insights, arguments, and capabilities. This had the effect of raising the mean status of the entire group. I believe this was a very significant finding and it cements my resolve to continue to address status effects and my commitment to the practice of number talks.

Self-Theories

When polled about how they view their own intelligence, people fall somewhere between entity and incremental self-theories. Many students in my two classes identified with an entity theory and tended to view their intelligence as something they had a limited quantity of. Many of these learners were initially afraid to fail and saw challenges as potential threats, believing that performance and intelligence are directly connected. However, over time, with targeted intervention, this action research project showed that these entity self-theories could be gradually shifted toward incremental theories. At this incremental end of the spectrum I found students in our class who believed their amount of intelligence could be changed, that saw challenges as opportunities, and that stated they would rather learn something new, even if it meant not getting a good grade. Research has shown that student's self-theories can be changed, and that moving students from entity (fixed) self-theories to incremental (growth) self-theories has a positive effect on learning outcomes that continues to pay dividends over time (Heyman & Dweck, 1998; Dweck, 2000; Blackwell et al., 2007). In completing his action research project, I found that number talks were a potential vehicle for delivering and reinforcing incremental self-theories. During the course of this project, class average expressions of self-theory became more incremental and less entity oriented. Students' belief in their own ability to possess and wield many types of math smartness increased measurably. I believe this was precisely because of number talks.

Implications For My Teaching Practice

Number talks have shown me that a single effective practice can embody so much, from teaching philosophy and content knowledge, to effective pedagogy. Implementing number talks with intentionality, backed up with data collection, gave me concrete insight into many positive things that were occurring for students. I have seen that student status and self-theories can undergo measurable, positive change that has the potential to raise achievement levels and create a more engaging, satisfying learning community. I have seen that student's belief about their own and their peers' abilities can be directly impacted. Due to these findings, I believe the practice of number talks is indispensable for my future teaching practice. It is my goal to be able to move students from viewing math as an area of expert knowledge ruled over by the teacher, to viewing math as an area of engaging exploration in which everyone has multiple skill areas, where discourse and disagreement and mistake making become a fun yet intellectual activity.

Suggestions For Future Research

I hope that the practice of number talks becomes the subject of more available peer-reviewed research. My action research project showed me that the practice holds much potential for improving educational outcomes. If that is indeed the case, an increased focus on the practice could bring it into wider use, expanding the positive impact and allowing practitioners the opportunity to continue to refine it. One area of deeper research might be to obtain data on what the immediate and ongoing academic outcomes of students might be when they have been taught math using number talks, as compared with students learning from more traditional practices. It would also be of great interest to me to examine correlations between ongoing status and self-theories and academic achievement and long-term outcomes. I would highly encourage classroom teachers to engage in action research projects around number talks, and for them to share their results with other teachers so we can all benefit from their insights and experiences.

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APPENDIX A

Math Status Survey Form

NAME:______________________________ DATE:____________________

Math Class Survey

Below is a list of students from this class with name (codes).

In the blanks below, put the name code of any person in class you think is *smart at math*.

Be sure to include yourself if you think you are smart at math too!

WRITE THE 3-DIGIT CODE, NOT THE NAME

CODE:	CODE:	CODE:	CODE:
Example: 123			

M1A* (266)
M1B (751)
M1C (640)
M1D (152)
M1E (426)
M1F (986)
M1G (465)
M1H (402)
M1I (719)
M1J (663)
M1K (572)
M1L (547)
M1M (115)
M1N (724)
M1O (196)
M1P (337)
M1Q (140)
M1R (312)
M1S (462)
M1T (706)
M1U (165)
M1V (711)
M1W (360)
M1X (386)

* Original surveys had actual student names here - i.e. Dannie (266), etc.

APPENDIX B

Math Status Survey Results

Math Class 01 (M1) Math Status Survey - % of class that thinks student is 'smart at math'					Math Class 02 (M2) Math Status Survey - % of class that thinks student is 'smart at math'				
Student	Smartness Survey 01	Smartness Survey 02	Smartness Survey 03	% Change	Student	Smartness Survey 01	Smartness Survey 02	Smartness Survey 03	% Change
M1A	.67	.68	.68		M2A	.43	.79	.76	
M1B	.46	.32	.45		M2B	.35	.42	.17	
M1C	.50	.55	.64		M2C	.43	.32	.17	
M1D	.46	.36	.36		M2D	.57	.68	.59	
M1E	.42	.41	.45		M2E	.39	.42	.65	
M1F	.67	.68	.77		M2F	.35	.47	.47	
M1G	.58	.64	.77		M2G	.30	.79	.94	
M1H	.63	.77	.77		M2H	.30	.68	.59	
M1I	.29	.41	.41		M2I	.26	.58	.47	
M1J	.42	.55	.64		M2J	.26	.32	.29	
M1K	.38	.50	.59		M2K	.47	.63	.71	
M1L	.71	.82	.82		M2L	.30	.58	.59	
M1M	.50	.64	.73		M2M	.52	.89	.88	
M1N	.33	.59	.68		M2N	.30	.53	.53	
M1O	.25	.36	.32		M2O	.39	.63	.47	
M1P	.54	.59	.68		M2P	.57	.89	.94	
M1Q	.50	.45	.41		M2Q	.30	.58	.29	
M1R	.29	.36	.32		M2R	.26	.53	.53	
M1S	.29	.41	.45		M2S	.61	.74	.76	
M1T	.50	.41	.59		M2T	.43	.63	.76	
M1U	.42	.55	.55		M2U	.17	.26	.29	
M1V	.33	.59	.50		M2V	.39	.58	.71	
M1W	.42	.64	.77		M2W	.22	.42	.71	
M1X	.42	.55	.77		M2X	.57	.89	.82	
Class Avg	**.46**	**.53**	**.59**	**+28%**	**Class Avg**	**.38**	**.59**	**.59**	**+55%**

Status score is simply the % of students from each class that said this individual is 'smart at math'.
If all the students in the class said an individual was 'smart at math', their score would be 1.0
If none of the students in the class said an individual was 'smart at math', their score would be 0.0

For example: during survey 03 of Math Class 02, 88% (.88) of the class said that Student M2M was 'smart at math'.

In Math 1, students average status rose by 28%
In Math 2, students average status rose by 55%

APPENDIX C

Self-Theory Survey Form

NAME:______________________________ DATE:____________________

Smartness Theories Survey

Read each sentence below and then circle the *one* star that shows how much you agree with it. There are no right or wrong answers.

		NO! I Really **Disagree**	I Disagree	I Kinda Disagree	I Kinda Agree	I Agree	**YES! I** Really **Agree**
1.	**I have a certain amount of intelligence, and I really can't do much to change it.**	☆	☆	☆	☆	☆	☆
2.	**My intelligence is something about me that I can't change very much.**	☆	☆	☆	☆	☆	☆
3.	**I can learn new things, but you can't really change your basic intelligence.**	☆	☆	☆	☆	☆	☆
4.	**No matter who you are, you can change your intelligence a lot.**	☆	☆	☆	☆	☆	☆
5.	**You can always greatly change how intelligent you are.**	☆	☆	☆	☆	☆	☆
6.	**No matter how much intelligence you have, you can always change it quite a bit.**	☆	☆	☆	☆	☆	☆
7.	**If I knew I wasn't going to do well at a task, I probably wouldn't do it, even if I might learn a lot from it.**	☆	☆	☆	☆	☆	☆
8.	**I sometimes would rather do well in class than learn a lot.**	☆	☆	☆	☆	☆	☆
9.	**It's much more important for me to learn things than it is to get the best grades.**	☆	☆	☆	☆	☆	☆
10.	**If I had to choose between getting a good grade and being challenged in class, I would choose…**		Good Grade			Being Challenged	

Adapted from Carol Dweck, 2000

APPENDIX D

Self-Theory Survey Results

Class: M1 Self-theory Ratings Over Study Period				
Student	SE Surv 01	SE Surv 02	SE Surv 03	% change
M1A	-	1.2	0.44	- 63%
M1B	2.0	-	0.4	-80%
M1C	2.2	2.0	2.0	-9%
M1D	4*	4.4	4.9	+23
M1E	1.7	1.8	-	+6
M1F	2.0	2.3	1.5	-25
M1G	2.0	2.4	2.8	+40
M1H	2.4	1.6	2.3	-4
M1I	-	3.7	3.25	-12
M1J	4*	-	2.44	-39
M1K		-	2.9	n/a
M1L	3.0	2.5	3.11	+4
M1M	-	2.0	-	n/a
M1N	2.9	2.06	1.35	-54
M1O	2.8	-	3.1	+11
M1P	2.2	2.6	2.4	+9
M1Q	3.4	2.6	2.8	-18
M1R	3.0	3.0	2.78	-7
M1S	3.5	1.5	0.6	-83
M1T	3.2	3.3	3.8	+19
M1U	2.4	1.6	1.4	-42
M1V	3.1	1.9	2.0	-35
M1W	2.6	1.9	1.6	-38
M1X	0.85	1.1	1.1	+29
Class Avg	**2.66**	**2.3**	**2.23**	**-16**

Class: M2 Self-theory Ratings Over Study Period				
Student	SE Surv 01	SE Surv 02	SE Surv 03	% change
M2A	4.0	3.1	2.3	-42%
M2B	2.8	2.8	-	0
M2C	2.8	-	-	n/a
M2D	1.2	1.65	-	+38
M2E	2.5	-	-	n/a
M2F	2.5	1.8	1.6	-36
M2G	2.7	1.8	1.5	-44
M2H	2.2	0.4	0.8	-64
M2I	1.4	-	-	n/a
M2J	2.7	2.0	-	-26
M2K	2.9	1.8	2.0	-31
M2L	3.0	2.4	2.0	-32
M2M	1.4	0.55	1.0	-29
M2N	1.6	2.35	2.1	+31
M2O	2.2	2.7	2.9	+32
M2P	1.8	1.8	1.8	0
M2Q	2.7	2.3	2.9	+7
M2R	2.4	1.9	0.9	-62
M2S	1.6	1.7	1.4	-12
M2T	2.6	2.3	2.05	-21
M2U	2.1	-	-	n/a
M2V	1.6	2.4	1.5	-6
M2W	1.3	-	1.4	+8
M2X	3.4	3.8	2.65	-22
Class Avg:	**2.31**	**2.08**	**1.81**	**-22**

Self-theory rating scale:
1 = lowest possible (absolute incremental)
4 = highest possible (absolute entity)

APPENDIX E

Math Smartness Survey Form

NAME:______________________________ DATE:____________________

Math Smarts Survey

In what ways are you "smart" at math? (circle all of the things you are good at). Everyone is good at some of these things and no one is good at all of them.

I am good at building models	*I am good at making predictions*	*I am good at finding patterns*
I am good at drawing diagrams	*I am good at remembering vocabulary*	*I am good at estimating*
I am good at organizing information into lists and tables	*I am good at arguing*	*I am good at visualizing*
I am good at explaining my thinking out loud	*I am good at using symbols*	*I am good at asking questions*
I am good at explaining my thinking on paper	*I am good at remembering rules*	*I am good at following directions*
I am good at revising my thinking	*I am good at finding similarities and differences between things*	*I am good at calculating quickly in my head*
I am good at finding my mistakes	*I am good at taking guesses*	*I am good at coming up with examples*
I am good at mapping things out	*I am good at listening to others' ideas*	*I am good at...*

Pick 3 of the things that you are not good at *YET* (things you did not circle above), and write them here:

Three things I would like to get better at are:

(1) ____

(2) ____

(3) ____

Adapted from Mandy Hubbard, 2006

APPENDIX F

Math Smartness Survey Results

Class: M1 Number of 'math smarts' selected per survey:					Class: M2 Number of 'math smarts' selected per survey:				
Student	Smartness Survey 01	Smartness Survey 02	Smartness Survey 03	% Change	Student	Smartness Survey 01	Smartness Survey 02	Smartness Survey 03	% Change
M1A	12	20	21	+75	M2A	10	12	12	+20
M1B	8	11	23	+188	M2B	8	8	absent	0
M1C	10	10	11	+10	M2C	8	absent	10	+25
M1D	10	8	4	-60	M2D	13	10	absent	-23
M1E	12	10	absent	-17	M2E	3	absent	absent	n/a
M1F	13	12	13	0	M2F	19	20	20	+5
M1G	10	8	13	+30	M2G	21	17	20	-5
M1H	12	11	18	+50	M2H	6	14	16	+167
M1I	23	23	23	0	M2I	8	absent	absent	n/a
M1J	17	absent	7	-59	M2J	19	13	absent	-32
M1K	7	absent	10	-43	M2K	12	10	16	+33
M1L	5	7	7	+40	M2L	18	16	14	-22
M1M	16	12	absent	-25	M2M	13	17	20	+54
M1N	7	12	9	+29	M2N	4	10	5	+25
M1O	5	4	9	+80	M2O	18	16	20	+11
M1P	19	15	12	-37	M2P	10	11	8	-20
M1Q	10	17	21	+110	M2Q	3	10	7	+133
M1R	8	12	13	+63	M2R	21	22	22	+5
M1S	16	10	11	-31	M2S	16	14	18	+13
M1T	9	9	8	-11	M2T	12	12	11	-8
M1U	11	16	15	+36	M2U	6	absent	absent	n/a
M1V	9	11	6	-33	M2V	4	4	6	+50
M1W	11	12	12	+9	M2W	11	absent	11	0
M1X	19	23	22	+16	M2X	absent	20	23	+15
Class Avg	**11.62**	**12.41**	**13.09**	**+13%**	**Class Avg**	**11.43**	**13.47**	**14.38**	**+26%**

Number of math smartnesses selected by each student per survey.
M1 self-identified smartnesses increased by 13% over the study period.
M2 self-identified smartnesses increased by 26% over the study period.

APPENDIX G

Number Talk Survey 2 Form

Number Talks Survey

Color in the bars that show how you think about each question

---

1. How smart do you feel at math?

Not Smart At All		A Little Smart		Very Smart

2. Do you feel like you are getting smarter at math?

Not Getting Smarter		Staying About The Same		Getting Much Smarter

3. Do you think number talks are helping you get smarter at math?

Not Helping My Math Smarts		Maybe Helping A Little Bit		Helping My Math Smarts A Lot

4. Do feel like you to talk enough during number talks?

Don't Talk Enough		Talk Sometimes		I Talk Enough

5. Do you feel like other people listen to what you have to say during number talks?

They Don't LIsten To Me		They Listen Sometimes		They Listen To Me A Lot

6. Do you feel like a number talk is a safe place to say what you think?

Not A Safe Place		Sometimes Safe		A Very Safe Place

7. Have number talks changed how math smart you thought some people are?

Hasn't Changed		Changed A Little		Changed What I Thought A Lot

8. Have you ever learned something new from another student during a number talk?

Never Learned Something New		Maybe One Or Two Things		I Have Learned A Lot Of New Things

9. Have number talks changed how you feel about other students' math smartness?

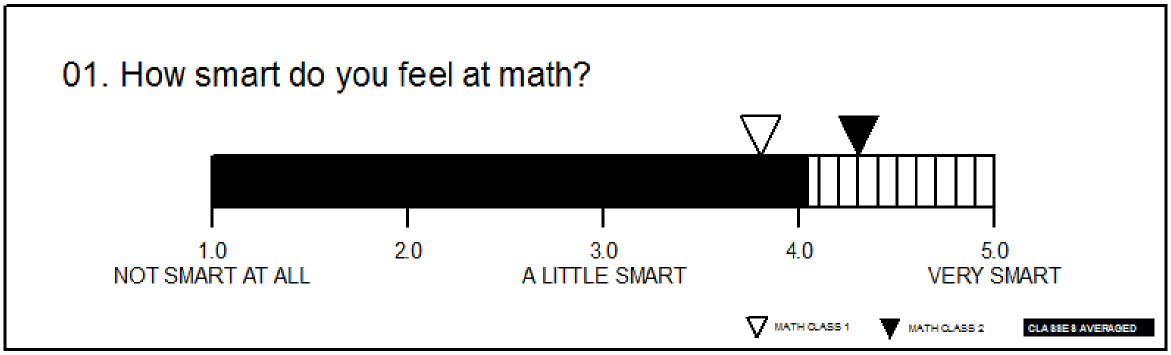
Hasn't Changed How I Feel		Changed It A Little		Has Changed How I Feel A Lot

10. If you got to vote on number talks would you say to quit doing them or to keep doing them?

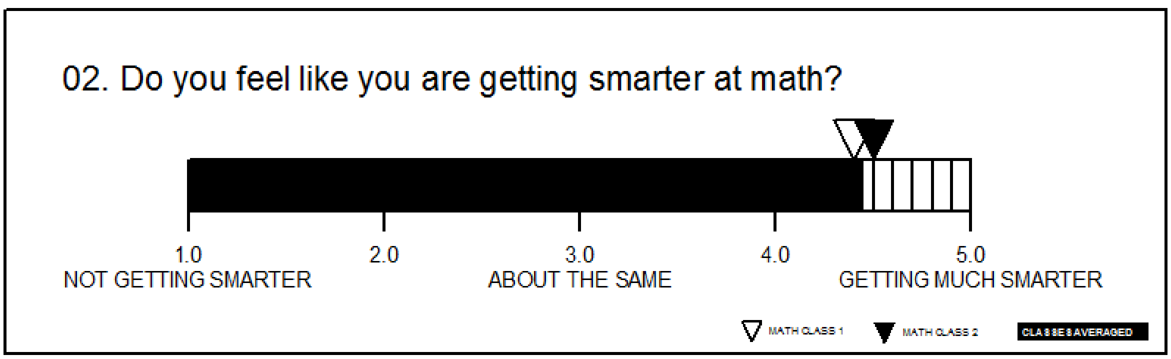
Quit Doing Them At All		Do Them Sometimes		Do Them A Lot

APPENDIX H

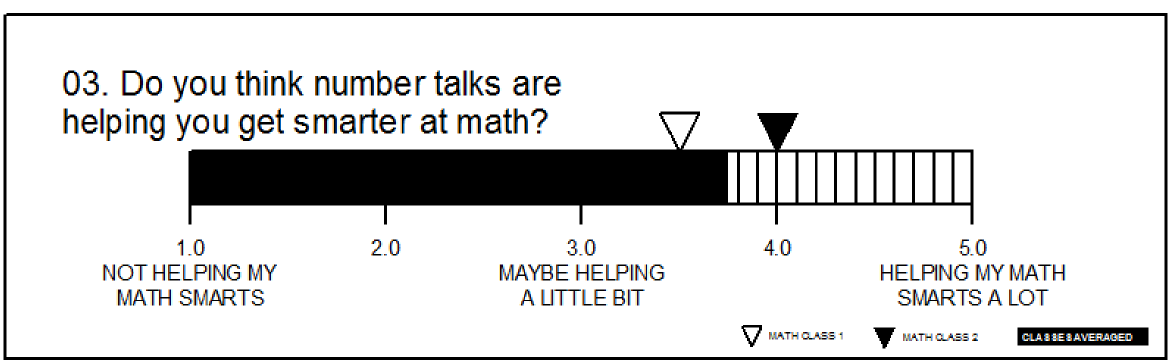
Number Talk Survey 2 Results



M1 - 3.8
M2 - 4.3
AVG - 4.05 (76%)

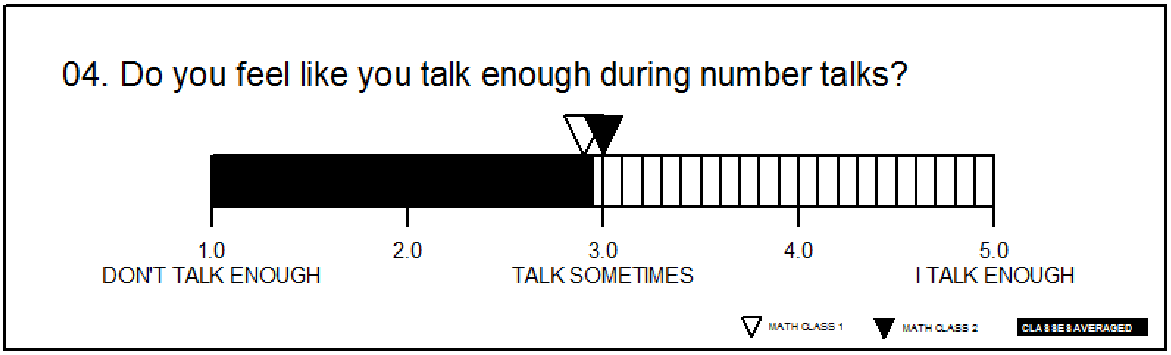


M1 - 4.4
M2 - 4.5
AVG - 4.45 (86%)

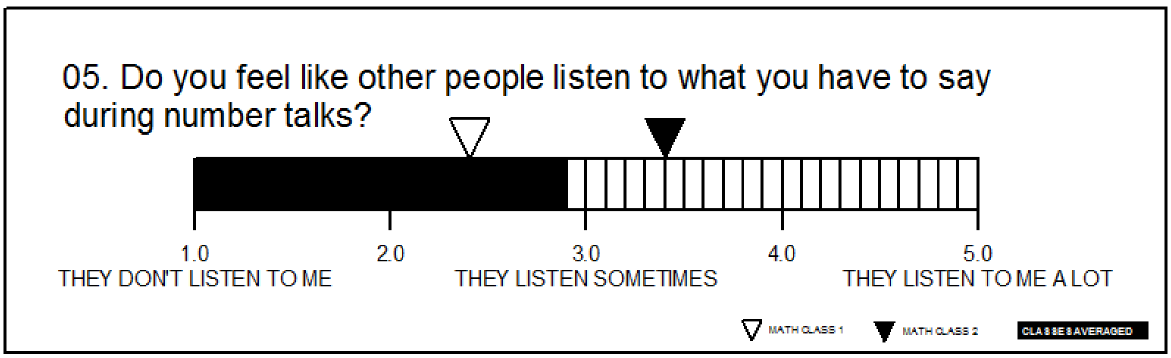


M1 - 3.5
M2 - 4.0

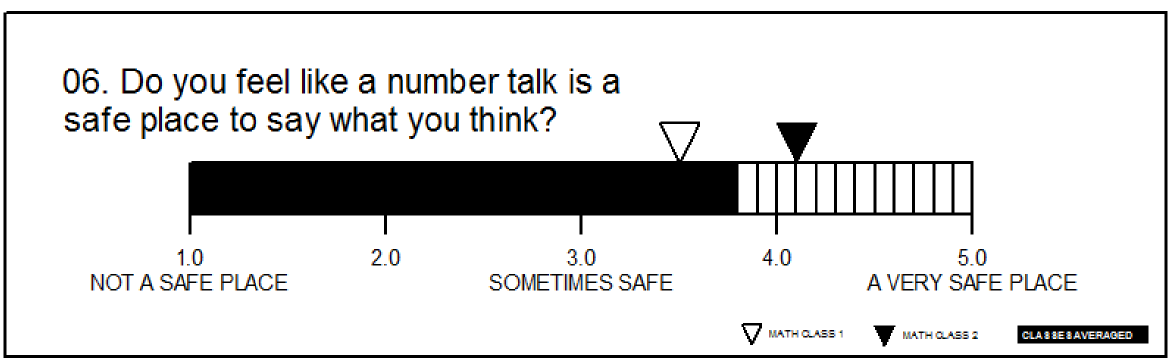
AVG - 3.75 (69%)



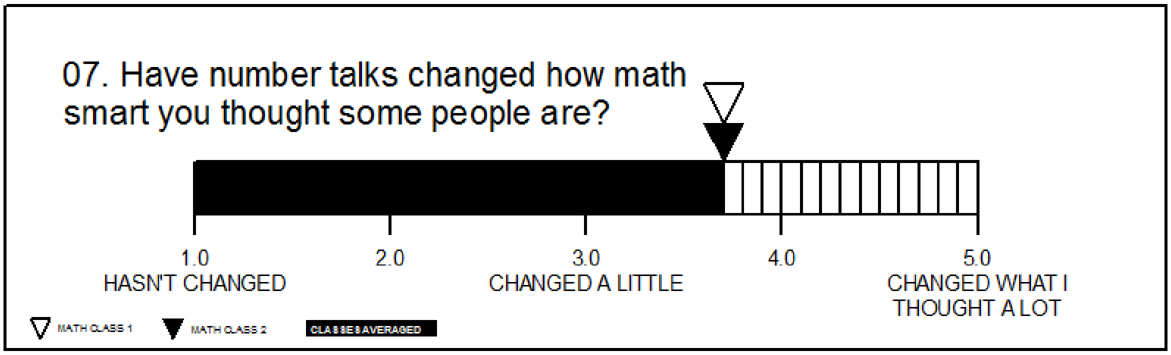
M1 - 2.9
M2 - 3.0
AVG - 2.95 (49%)



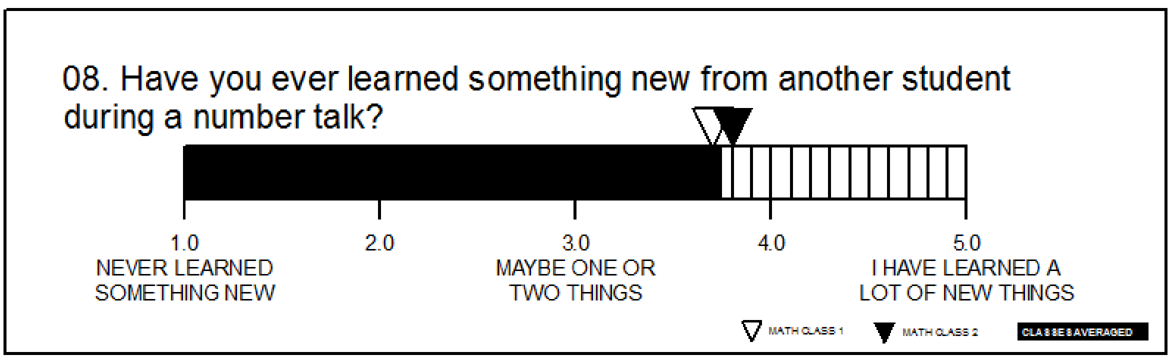
M1 - 2.4
M2 - 3.4
AVG - 2.9 (48%)



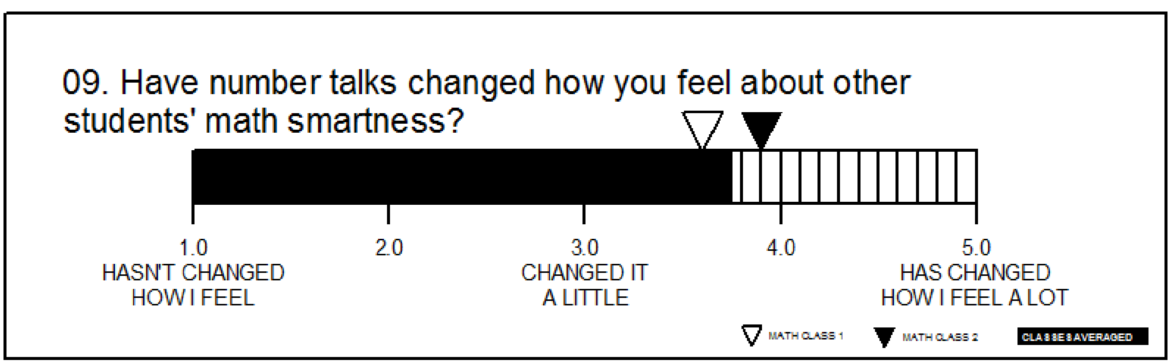
M1 - 3.5
M2 - 4.1
AVG - 3.8 (70%)



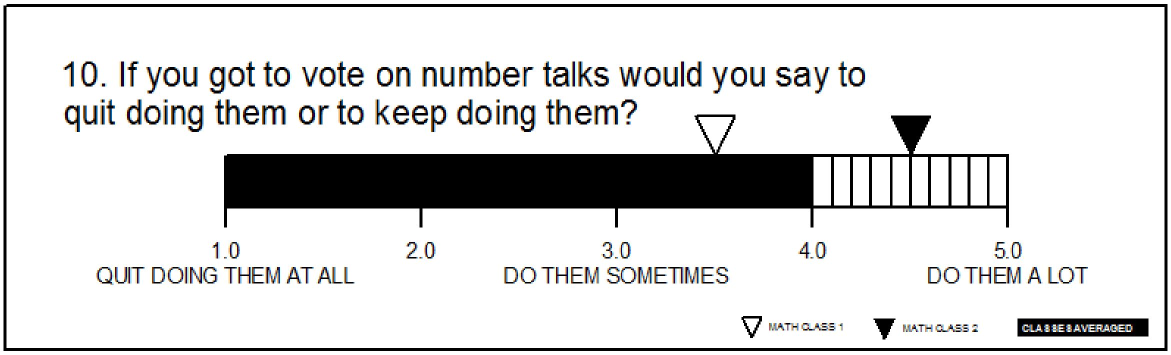
M1 - 3.7
M2 - 3.7
AVG - 3.7 (68%)



M1 - 3.7
M2 - 3.8
AVG - 3.75 (69%)



M1 - 3.6
M2 - 3.9
AVG - 3.75 (69%)



M1 - 3.5
M2 - 4.5
AVG - 4.0 (75%)

APPENDIX I

Student Interview Questions

NUMBER TALK STUDENT INTERVIEW

Student Name: ________________________________ Date: ____________

SELF EFFICACY

1. Remember our Math Smartness Surveys? (show blank copy)
    a. How do you feel about your Math Smartness?

    b. Do you feel like you are getting smarter in math?

2. Do you think number talks have helped improve your math smartness?
    a. Why or why not?

STATUS

3. Do you think everyone gets heard during a number talk?
    a. Who does get heard?
    b. Who doesn't get heard?
    c. Why do you think that is?

4. During number talks, have you heard a strategy from another student you thought was useful or interesting?
    a. Have you heard a strategy that changed your thinking?
    b. Have ever you heard someone who you didn't think was smart at math say something useful or interesting?

5. Have number talks changed what you thought about other people's math smartness?
    a. If so, in what way?

APPENDIX J

Potential Number Talk Mitigation to Instructional Barriers

Category	Potential Barrier posed by Traditional Instruction	How Number Talks May Address Barrier
Instructional Practices	Traditional, teacher-centered instruction focused more on speedy accuracy than conceptual understanding.	Number talks provide student-centered instruction where overwhelming focus is to tease out conceptual understanding and student thinking.
	Traditional, teacher-centered instruction diminishes student autonomy in learning process, leading to lower motivation.	Number talks are student-centered and focus is on student response, not teacher-as-lecturer. The format is problem-posing, encouraging student freedom in developing and pursuing their own understanding of the concepts and methods for arriving at mathematical solutions.
	Traditional, teacher-centered instruction tends to be univocal (lectures) instead of dialogic (students engaged in creating, stating, and defending their mathematical thinking).	Number talks encourage dialogic discourse while minimizing teacher centered lecture.
	Math as an isolated, overly-cerebral, individualistic activity generally disconnected from real life.	Number talks format mathematical concepts as immediate, tangible exercises, often as visual patterns or puzzles. Focus is on student engagement and peer-collaboration in elucidating understanding, not on individual technical calculations.

Category	Potential Barrier posed by Traditional Instruction	How Number Talks May Address Barrier
Teacher Beliefs	Teacher's belief that some students can't learn complex math leads to ability grouping/tracking in homogeneous classrooms.	Gives teacher avenue to engage all students (regardless of current ability) in mathematical thinking & dialogue. Gives teacher the opportunity to show a belief in all students to participate and learn challenging concepts.
	Teachers reserving complex, challenging math for high-achievers and simple, rote math for low-achievers.	Allows teacher opportunity to present heterogeneous ability group math of varying degrees of difficulty (especially if opportunity is taken during the process to continually work to deepen/extend).
	Teacher's belief that there are a limited number of correct ways to do math.	Allows teacher to witness and tap into the variety of student processes that will emerge. These should serve to help teacher better understand student-thinking while widening teacher repertoire for techniques to guide students toward understanding of the concepts.
	Teacher bias toward/against certain students based on cultural, linguistic, social status, etc.	Allows teacher to see students in a different learning context so they are given opportunities to recognize and combat their biases.

Category	Potential Barrier posed by Traditional Instruction	How Number Talks May Address Barrier
Culturally Relevant Teaching	Cultural, linguistic, social differences between teacher and students negatively affect communication and understanding in both directions.	Number talks provide a variety of activities that may enhance understanding/connections. Use of visuals, hand signals, and increased opportunities for student dialogue, all in the context of there being many right ways to find the answer may increase possible points of connection between students and teacher.
	Cultural, linguistic, social differences between students affecting peer-to-peer communication and understanding.	Same as teacher-student communication/connections above.
	Cultural, linguistic, social learning styles of some students not addressed (lack of differentiation).	Number talks present mathematical learning in a different context that may mesh with some student's learning styles not addressed by traditional instruction. Number talks frequently use peer-collaboration, visualizations, graphs/charts, images, chanting (rhythm/musical connections), dialogue, demonstrations and extended explanations of student thinking which deepens access for a variety of learners.

Category	Potential Barrier posed by Traditional Instruction	How Number Talks May Address Barrier
Status	Students identified as low-status typically get less attention, access and reinforcement to mathematics tasks, depressing their ability to learn.	Number talks provide a high-density opportunity for teachers to work on countering status effects, highlighting achievement of both high and low-status students overtly. This has the potential to create a positive feedback loop amongst mathematically competent low-status students, raising their access level to complex math.
	Imbalanced attention toward high-status students and away from low-status students fails to maximize diverse and novel student approaches to understanding/doing mathematics potentially held by low-status students.	Number talks provide fluid, dynamic forum where ideas from all students may be accessed. This allows students with many diverse approaches, ideas and techniques to share them while learning something new from other students who do things differently.
	Imbalanced attention toward high-status students and away from low-status students may reinforce societal status positioning, depressing motivation of low-status students and potentially diminishing feelings of connection and community. Creating an environment where students have incentive to opt-out of learning decreases the learning potential of all students in the room - the opt-outs due to disengagement and the opt-ins due to exposure to fewer ideas.	Number talks provide a concentrated location for teacher to work on minimizing effects of status. This provides students with not only real access via increased instructional involvement of lower-status students, it also models to the group an ethos of fairness, equity, inclusion, and value of diversity. This modeling should serve to reinforce group cohesion and norms that allow successful instruction while working to open student views on larger social-justice foundations.

Category	Potential Barrier posed by Traditional Instruction	How Number Talks May Address Barrier
Self Theories	Low-achieving entity-theory students don't believe they can get better at math.	Number talks provide an environment where students can be induced directly toward incremental theory versus entity theory, potentially changing the way they view their ability to learn math. Number talks also provide opportunity for students to actively observe other students learning and improving their math skills in an engaged, visible forum. This potential modeling by other students of incremental growth may additionally assist in students' move of self-theories from entity toward incremental.