USING NUMBER TALKS TO SUPPORT STUDENT AUTONOMY

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ABSTRACT

Supporting student autonomy is an important element of classroom pedagogy that has great potential for improving student engagement and learning outcomes. Additionally, supporting students' development of an incremental theory of self has been shown to positively impact students' academic trajectory. This action research project looks at how teachers can introduce autonomy support and incremental theory into their classroom practices through the number talk model.

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This project is dedicated to my future students, and to my dear husband.

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CHAPTER 1—INTRODUCTION

Problem Statement

Supporting teacher and student autonomy and motivation in this era of No Child Left Behind (NCLB), high-stakes standardized testing, and Common Core aligned curricula, can seem a daunting task. Teachers must work purposely and diligently in order to build classroom communities that are supportive of student learning. Many school districts and teachers, in an attempt to ensure that their students are able to pass standardized tests, have switched to teacher-centered curricula and have sought to improve test scores by using rewards and punishments to motivate students to learn. In short, they have increased their use of extrinsic motivation, and have reduced student, as well as teacher, autonomy. The Green Creek School District[1], where I completed my student-teaching, is one such school district that uses school-wide and in-class reward and punishment systems in attempt to increase student learning. These extrinsic motivators limit students' autonomy, which has well-documented effects on students' motivation and achievement (Zull, 2002; Dweck, 2000).

One possible method to attempt to improve student learning is to attend to how students' perceptions of autonomy are affected by student-teacher interactions. Of particular relevance are students' perceptions of control over their own learning and their belief in either an entity or incremental theory of intelligence (Dweck, 2000). With in this model, a student who has developed an incremental theory of intelligence believes that their intelligence can be increased by practice and effort. Students with an entity theory of intelligence believe that their intelligence is fixed and that they have no ability to improve their ability. When a student with an incremental

[1] All names are pseudonyms.

theory of intelligence is challenged by a difficult problem or concept, they are better able to persevere and increase their effort to learn. However, when a student in an entity theory of intelligence runs into difficulty understanding in school, they may believe that they “just aren’t good” at school, and often refuse to continue their attempts to learn. Theories of intelligence are clearly linked with students’ concepts of their own self-efficacy. A student with a high sense of self-efficacy believes that they are able to learn and take on academic challenges successfully, while a student with low self-efficacy is more likely to believe that they are incapable of meeting an academic challenge. Teachers can create more autonomy-supportive and intrinsically motivating environments by attending to the environment they create through their verbal interactions with students (Reeve & Jang, 2006). Examples of autonomy support include offering meaningful choices, pushing students to be able to justify their answers with mathematical reasoning, and structuring instruction so that students discover concepts and build their own understandings. This is in contrast to traditional practices where teachers present the material as discrete units of information to be memorized and provide answers and procedures without developing students' understanding of underlying math concepts.

Number talks are one instructional model that could be used to give all students access to mathematical concepts and relationships. Number talks can also serve as a structure to increase and support students' motivation and autonomy, while also supporting students’ self-efficacy in regards to mathematical ability (Reeve & Jang, 2006; Truxaw and DeFranco, 2008). This is indeed crucial for students who have been marginalized by traditional standards of what it means to be smart in math, which focus primarily on quick thinking and memorization of formulas and procedures. Additionally, number talks give students many opportunities to develop a mastery orientation towards math, which will benefit them in their later academic careers.

I propose that number talks can also be used to examine the use of classroom dialog in order to better support student autonomy. This model of math instruction works to place student thinking and mathematical reasoning at the center of instruction, rather than correct answers and students' ability to apply the standard algorithm, regardless of whether they actually understand the underlying math concepts (Yackel & Cobb, 1996). Number talks also differ from more traditional forms of instruction mainly in the discourse styles and structures that teachers create. Focusing on teacher talk in the classroom is useful because relatively simple changes in classroom dialog patterns—such as from a teacher-led monologue to a more dialogic discourse—could enhance student enjoyment, engagement, and intrinsic motivation via increased autonomy support. This would result in increased student understanding and improved long-term learning outcomes (Truxaw and DeFranco, 2008).

In my research, I will focus on how the model of a number talk can be used to support students' autonomy in a moderately traditional classroom setting. I will focus on the elements of autonomy support in the existing number talk model. Instructional styles within Green Creek School I have been able to observe have tended to be more traditional and teacher-centered. One possibility for increasing learning among all students in this environment is a combination of increased autonomy support within the classroom, attending to the effects of status on learning, and incorporating incremental theory into the classroom talk. A classroom environment that supports student autonomy and is student-centered has potential for improving learning by increasing engagement among students. The methods involved in number talk-centered instruction might improve learning outcomes among all students, including students with currently low grades, low mathematical confidence, and low mathematical self-efficacy.

Review of the Literature

Autonomy, Incremental Theory, and Motivation

Increased external controls do not tend to increase learning (Deci & Flaste, 1995; Reeve 2012). This is because ultimately, it is the learner who controls what is learned, how it is learned, and when it is learned (Zull, 2002). Additionally, attempting to exert control over another tends to elicit rebellion, rather than compliance, as individuals struggle to maintain their sense of autonomy and freedom (Zull, 2002; Deci & Flaste, 1995). When teachers neglect to support the autonomy of their students, and instead rely on a more controlling motivational or extrinsically motivating style, students may suffer many detrimental effects including negative affect, a lack of relatedness to their teacher, reduced engagement, reduced creativity, and an externalized locus of control (Deci & Flaste, 1995; Reeve, 2009). On the other hand, when teachers create classroom environments that support autonomy and intrinsic motivational drives (Deci, 1995), students feel more competent, have greater creativity, and understand the lesson material more deeply. Students are also more likely to be active in the information processing, more engaged, have higher intrinsic motivation, and greater academic performance and persistence (Reeve, 2006). Students who have become intellectually autonomous are more "aware of, and draw on, their own intellectual capabilities" rather than being dependent on teachers to provide the right answers (Yackel & Cobb, 1996, p. 473). Relying on external motivators has two additional major drawbacks. First, once the motivating force is removed the behavior it was maintaining disappears. Second, the imposition of controlling external motivators elicits rebellion and refusal to comply with expected rules. No matter how much effort teachers put into motivating students, they cannot make an unwilling student learn; therefore, it is best for teachers to instead create an environment that fosters students' own intrinsic motivation and directs students toward the content to be learned (Yackel & Cobb, 1996). In this study, researchers worked with cooperating second and third grade teachers in whole-class settings, and collected data in the form of video recordings for the entire school year's mathematics lessons, along with field notes and copies of students' work from a second grade classroom. Additionally, the researchers conducted interviews with students in the beginning, middle, and end of the school year. Videos were analyzed to observe the interactions between students and teachers, the negotiation of meaning and mathematical sense making, as well as the development of a classroom discourse. Interactions were then analyzed to determine how they lead to student understandings of expectations within the discourse culture of the classroom. This study has several markers of quality, including a rich and thick description, and collecting and triangulating multiple sources of data (Yackel & Cobb, 1996).

How then can teachers create autonomy-supportive classrooms? And how can we measure motivation within the classroom? Research has revealed that autonomy-supportive classrooms share several key characteristics and differ from controlling classrooms in distinctive ways. For those studying the effects of intrinsic motivation and autonomy, measurements of student engagement are used to determine how autonomy-supportive academic environments are. However, because intrinsic motivation and feelings of autonomy are internal conditions, they cannot be measured directly. As motivation and engagement are inherently linked, researchers use engagement, which is a more public, observable effect, to track the internal state of students' motivation. Autonomy-supportive classroom environments have been well demonstrated to improve student engagement (Reeve, 2012). Highly engaging and autonomy-supportive classrooms are characterized by being highly structured (Deci, Jang, & Reeve, 2010). Additionally, teachers and authority figures who provide explanatory rationales, use of informational rather than controlling language, patience, and acceptance of students' emotions, while also providing clear and consistent expectations, modeling cognitive processes, scaffolding understanding, and encouraging students to self monitor and assess (Reeve, 2009; Rapheal, Pressley & Mohan, 2008) are also important hallmarks of autonomy-supportive and engaging classrooms. According to Self-Determination Theory:

> Students possess inherent needs and growth propensities to constructively engage their sociocultural surroundings. These surrounds, in turn, feature conditions that tend either to support or thwart students' motivation. To the extent that students are able to express themselves and master classroom challenges, the dialectal outcome with be synthesis, resulting in greater autonomy and well being. But to the extent that the controlling and motivating forces in classrooms overpower students' proactive (autonomous) engagement, synthesis will be impaired and less optimal outcomes will result (Reeve, Deci, and Ryan, 2004; p. 41).

Autonomy-supportive teachers design lessons that build students' understanding while also engaging and motivating their students, making clear both classroom expectations and the reasons underlying these expectations. In short, autonomy-supportive teachers respect students and create environments where students feel safe to explore and test out their understandings. Much of the autonomy-supportive environment is created by teachers' choices in how they communicate verbally.

In addition to supporting student autonomy, helping students to build an incremental theory of intelligence is a powerful predictor of their future academic success (Dweck, 2000). Briefly, individuals who hold entity theories of intelligence believe that 'smartness' is a fixed trait that cannot be altered. On the other end of the spectrum, individuals who hold an incremental theory of intelligence believe that through applying effort and practice, one can actually increase one's intelligence and ability (Dweck, 2000). Students with stronger incremental theories of intelligence also select

> stronger learning goals, hold more positive beliefs about effort, and make fewer ability-based, "helpless" attributions, with the result that they choose more positive, effort-based strategies in response to failure, boosting mathematics achievement...(Blackwell, Trzesniewski, & Dweck, 2007, p. 258)

Thus, both autonomy and incremental theories of intelligence should be built into the structure of number talks if we are to help students attain greater mathematical achievement. An example of this occurred in a study conducted by Blackwell, Trzesniewski, and Dweck of adolescents transitioning into junior high school. The study tracked two groups of students over the course of a school year after an intervention during which the experimental group "were taught that intelligence is malleable and can be developed" and students in the control group instead "had a lesson on memory and engaged in discussion of academic issues of personal interest to them" (Blackwell, Trzesniewski, & Dweck, 2007, p. 254). Not only did the students in the experimental group have a stronger belief in incremental theory after the intervention, they also demonstrated long-term effects from the intervention that the control group did not benefit from. First, students who had endorsed a stronger entity theory of intelligence before the intervention saw the decline in their grades reverse, while students with an entity theory in the control group continued to see declining grades. Further, this study found that students' incremental or entity theories of intelligence were related to their grades during the next two years of their educational experience. The researchers conclude that

> in a supportive, less failure-prone environment such as elementary school, vulnerable students may be buffered against the consequences of a belief in fixed intelligence, However, when they encounter the challenges of middle school, these students are less equipped to surmount them. (Blackwell, Trzesniewski, & Dweck, 2007, p. 258)

Perhaps then, elementary school teachers should seek to equip their students with an incremental theory of intelligence, in order to help increase their students' future academic achievement and success. One method of accomplishing this would be to incorporate incremental theory and autonomy into the verbal structure of number talks.

Creation of Autonomy-Supportive Classrooms

As Stipek's (et al., 2001) research study shows, teachers' own beliefs in regards to their students' ability to improve their mathematical skills are strongly tied to teachers' own beliefs about what math is, how to motivate students, and how much autonomy to allow or support within the classroom. That is, teachers who believed that mathematical ability is a fixed quality also believed that mathematics is a set of procedures, focused on correct answers, and used extrinsic rewards and grades to tightly control their students' behavior in the classroom. Meanwhile, teachers who believed that mathematical ability could be improved considered math to be a tool for thinking, focused on students understanding of concepts, and supported students' autonomy while working to engage their students in learning by providing problems that were engaging. These findings show that is important for both teachers and students to develop incremental theories of intelligence if classrooms are to support student autonomy and the learning of math as a way of thinking, rather than as a set of procedures to memorize (Stipek et al., 2001).

While providing choice is a key element of supporting autonomy and intrinsic motivation, not all choices are created equal. In order to identify which factors make choice beneficial, Katz and Assor (2007) reviewed the literature surrounding choice and motivation, and found that offering choice was only a motivating force when the choice offered was meaningful. If the choices offered to students are not meaningful, then the offering of choice might instead reduce our students' motivation. When offering choice in our classrooms, we should make sure the proffered options are relevant to our students' interests and goals, are optimally challenging, and are sensitive to student's background cultures, in order to support their sense of autonomy and motivation (Katz & Assor, 2007). According to Reeve and Jang (2006), autonomy-supportive teachers allow—or encourage—students to talk through their learning, give praise as informational feedback, offer encouragement and hints, are responsive to students' questions, and take the students' perspective. These are the very instructional tools used to create number talk communities.

As Jang, Reeve, & Deci (2010) describe, student autonomy is not enough; a highly-structured classroom must be established, and then combined with autonomy support to create the most learning opportunities for students. It is teachers who create the structure of a classroom, and their ability to effectively teach is impacted by how much time can be devoted to instructional tasks rather than classroom management issues. Creating routines that both the teacher and students know and use is incredibility useful in this regard, and classroom operations become streamlined, faster, and more automatic. Leinhardt, Weidman, & Hammond (1987), examined the classrooms and routines of six teachers who had been identified as expert teachers as determined by student achievement growth scores over a five year period. This study is particularly important to my own action research, as the authors point out: "For novice and student teachers, tenuous classroom management often breaks down… resulting in classroom chaos and inefficient attempts to establish order" (Leinhardt, Weidman, & Hammond, 1987, p. 168). If I am to create an effective learning environment that supports student autonomy while also working to engender an incremental theory of intelligence, I will need to provide strong structures that support these agendas, and support my own use of time for instruction, rather than having my time consumed with behavioral and management issues. All of the teachers in the aforementioned study allotted a significant amount of time in the first few days of the school year to explicitly teaching and modeling the procedures required in their own classrooms. They also devoted considerable time to explaining the expectations of their classrooms. They used the first few days to introduce students into their unique classroom cultures and rehearse what would become the main routines for the classroom throughout the school year. This study also found that of these selected expert teachers, the most efficient manager also used and maintained the most management routines, and combined them in complex and powerful manners.

The research of Truxaw and DeFranco (2008) offers some insight into how different models of instruction use different kinds of conversational moves, particularly in relation to forms of verbal assessment and the role of discourse in the classroom. They found that in the inductive model of instruction, one where teachers work to support students' discovery of the concepts for themselves, teachers' assessments prompted students to actively monitor and regulate their own thinking while being taught, which was determined to be key to promoting dialogic discourse. Additionally, in the inductive classroom studied, there was a considerable amount of exploratory talk by students in their effort to build understanding. The students were also expected to support their ideas with reasoning and mathematical knowledge. In contrast, the deductive model is dominated by teacher talk, assessments, talk that leads students to the answer, and focused on conveying information to the students, rather than working with the students to develop their own concepts and understandings. Another difference between the models that were observed was the cyclical nature of the inductive classroom; talk circled back to previously discussed concepts as students returned to mathematical concepts. This allowed students to build their understanding and connect to previously learned mathematical concepts (Truxaw & DeFranco, 2008).

In another study looking at classroom discourse cultures, Chambers (2002) takes a closer look at two teachers who both value problem solving in their math classrooms, but who had significant differences in how engaged their students were. As in the study by Truxaw & DeFranco (2008), Chambers found that in what was termed the high-press classroom, where students were more engaged, students supported their explanations with mathematical reasons, were accountable for their work, and made connections between mathematical concepts and strategies. In addition, in this classroom, mistakes were treated as opportunities to explore mathematical ideas. In contrast, the classroom with less engaged students was described as having a sequence of strategies with no interconnection between math concepts and students were not pressed to explain their mathematical understandings. Furthermore, these two classrooms differed in how they scaffolded group work; in the more engaged, high-press classroom, students were required to make sure that each member of a group contributed to and understood the mathematics used in their solution. Further, their autonomy and incremental theories were supported by the teachers' insistence that they prove their answers mathematically during disputes, and come to agreement without the intervention of the teacher. In the less engaging, lower-press classroom, the teacher limited her instruction of group work to reminding the students to work together with a partner (Chambers, 2002).

One of the common concerns encountered by teachers implementing number talks in their classrooms is how to integrate students with low mathematical confidence and status with instructional model that seems to require confidence from students. Cohen and Lotan (1995) provided one strategy to support the inclusions of low status students in classroom activities, without decreasing the involvement of other students. Their research looked at the use of assigning competence to counteract status effects within the classroom. They found that when teachers provided feedback that was public, specific, valid, and related to the task at hand, both the student receiving the feedback and the remaining students in the classroom found the statements believable, and altered their perceptions of the student's math ability accordingly. Students who received this type of feedback thereafter had higher rates of participation in class, and more influence on their classmates (Cohen & Lotan, 1995). This in turn means more equitable access to learning within classrooms where teachers attend to status issues by assigning competency.

Another difficulty teachers might have when they begin to implement a more autonomy-supportive and engaging instructional practice is a reluctance to allow students to fail, even temporarily. These experiences are actually crucial in providing students opportunities to learn healthy coping mechanisms and perseverance. Additionally, for learning opportunities to be optimally challenging, there must be the potential for students to make mistakes. Mistakes are a key part of learning, and thus teachers must learn how to allow for mistakes during learning. Teachers must also learn how to support students' autonomy and incremental theories while experiencing temporary failure.

Number Talks as a Model for Supporting Autonomy

Number talks are a model of instruction that is intended to build students' abilities to reason mathematically, and learn to evaluate and think about mathematical strategies based on their mathematical worth, rather than the status of those who propose them (Parrish, 2010). Typically, number talks are approximately 10 to 15 minutes long, and are often used to introduce a new method or mathematical concept. Teachers prepare, in advance, a set of challenges presented in a manner that either implicitly guides students towards a desired strategy or allows students to generate and refine a range of strategies, deciding for themselves which are most useful and efficient. This is in opposition to the traditional method of explicitly directing students to use a particular strategy to solve a particular type of problem. The number talk may begin with problems that all students can solve easily, and progressively moves toward problems that are more challenging, and require scaffolding and cooperation from the whole group or class to successfully solve. Number talks are usefully flexible and can be easily adjusted to create more or less challenging problems to create the optimal level of challenge in response to student need. The goal of instruction is to create an environment where students become comfortable and practiced at sharing their ideas and applying others' strategies. Number talks also serve to support students' risk taking in attempting more challenging academic problems (Hufferd-Ackles, Fuson, & Sherin, 2004). This is a shift from the teacher as the primary, if not sole, knower, to the view that students can have mathematical ideas and strategies that differ from what the teacher expects, that these ideas may be correct, that students can learn from other students within the classroom, and that students are expected to be able to defend and explain their reasoning to the teacher and other students without backing down in the face of teacher authority. Within this method, as teachers and students adapt to the efforts required to create a number talk community, control over what is learned shifts between the teacher and the students, students become more responsible for their own and each other's learning, and students become responsible for determining whether their ideas have weight and are correct or not (Hufferd-Ackles, Fuson, & Sherin, 2004). This closely resembles what is expected within an autonomy-supportive classroom, wherein teachers recognize that students have responsibility and control over their own learning, and recognize that learning outcomes are benefited when teachers stop attempting to control learning, and start creating supportive environments for learning (Zull, 2002).

In number talk communities student learning is fostered by centering students on their own and other students' ideas, and their own ability to reason through to the mathematical answer. Students are pushed to use mathematical reasoning to solve problems posed to them rather than relying upon the teacher to teach them the right answer along with the right strategy to get that answer. This describes an expectation and environment that supports students' autonomy and sense of self-competency, rather than a reliance on rules and procedures imposed on the student from teachers and pre-designed curricula. This is not to say that this is a low-structure environment; rather, it is a high-structure, high-autonomy environment (Jang, Deci & Reeve, 2010) where teachers explicitly state expectations, make use of student intrinsic motivation in the lesson, use non-controlling and informational language, explain the rational and reasons behind the lesson, and accept and acknowledge their students psychological and emotional states (Reeve, Deci, & Ryan, 2004; Jang, 2008; Reeve, 2006). By using these key components of autonomy-supportive structures, number talks work to move toward a student-centered classroom, where the students ask questions and develop knowledge cooperatively. In this setting, teachers act as facilitators in creating the environment in which learning can occur, while providing the scaffolding and informational feedback that affirms student competency (Reeve, 2006; Yackel & Cobb, 1996).

One example of the effects of supporting students' autonomy in the context of a math class can be seen in the study conducted by Morrone, Harkness, D'Ambrosio and Caulfield in 2004. These researchers found that college-aged mathematics students

> became willing to engage in meaningful discourse about challenging mathematics problems because the teacher implicitly communicated to them her belief that they would be successful, not through praise, but by honoring their contributions to the classroom discourse. (p.35)

They also found that higher-order thinking is supported by classroom discourse that provides scaffolding for student learning and in which teachers press students to show their understanding. These practices also supported a mastery approach to learning in students (Morrone, Harkness, D'Ambrosio & Caulfield, 2004).

Research Question

I am interested in how teachers can support student-autonomy and encourage the development of an incremental theory of intelligence within the structure of a traditional classroom. My question is: How can I, as a beginning teacher, use the number talk model to support students' autonomy and development of an incremental theory of intelligence? I hope to observe how students' attitudes towards their own mathematical ability might be changed due to the introduction of an incremental theory of intelligence, along with autonomy-support. In order to support student autonomy and purpose in learning, teachers must make the most of our interpersonal interactions with the students within our classrooms. Reading the literature, it seems that much of autonomy-supportive behaviors are embedded in the dialectical styles of teachers. Thus, two teachers can teach the same lesson, and deliver it in either an autonomy-supporting or controlling fashion based on their style of communication, and the teachers'’ respect and empathy for their students’ intellectual and emotional needs. Additionally, it has been shown that introducing students to the incremental theory of intelligence can have a profound positive impact on their future academic careers. Once again, the structure of the number talk provides teachers a key tool in supporting and implementing support of student choice in the classroom.

CHAPTER 2—METHODS AND ANALYSIS

Participants and Setting

The setting for this study was a public elementary school serving a small, suburban community, adjacent to a large military base. Green Creek Elementary is set within the bounds of a middle-class neighborhood, with many families that are tied to the nearby military base. The school serves approximately 600 students from kindergarten to third grade, of primarily middle-class families. The students are predominately White, at 64% of the school’s population, and 12% receive free or reduced lunches. The school and community are very closely tied, with many parent volunteers and an active PTA.

One impact of the high percentage of military families is that the school's population is very mobile; as the military transfers students' parents around the nation, students are moved into and out of the area served by Green Creek. The high rate of student mobility provides an interesting lens through which to view the data, and presents an interesting question: will new students be immediately integrated into the classroom culture, or will there be a protracted period of adjustment? During the course of this ten-week study, our classroom population was fairly stable. One student joined our classroom towards the end of the data-collection period while five students were moved early in the school year to another classroom to adjust for class size.

Participants in this study were 27 third-grade students in my student-teaching placement classroom. Two students were regularly pulled out of the classroom during our number talks to receive specialized instruction. During the number talks, the remaining students relocated to the front of the room in front of the smart board and white board, both of which were used extensively during number talks. Students would come up to the white board or projector to show their thinking and strategies to the class, and I recorded students' answers and strategies on the white board. The expectation was that number talks would be a ten to fifteen minute introduction to the math lesson, which would lead into the remaining mathematical instruction for that day. However, sometimes the number talks extended past this time expectation as I sought to develop the students' understanding.

Methods

My research focused on using number talks to introduce and increase the use of autonomy-supportive teacher-talk in order to create an environment that is more supportive of autonomy and self-efficacy.

I began number talks during my student-teaching by presenting a mathematical problem, and asking students for their solutions and the strategies used to arrive at those solutions. Typically, I used wait time, silent methods of acknowledging that students had an idea ready, and other strategies to ensure that each student has had sufficient time to consider the problem and come up with an answer and solution. I then invited students to share their solutions, and their strategies, while withholding judgment of the solutions or the strategies. Students' strategies and answers were often recorded on the white board, either by me or by the student, and I highlighted when a student used the targeted strategy. I also asked students which strategy they think might be most useful, and encourage students to apply one of the strategies on the board to the math problems that follow. Students were encouraged to discover for themselves whether particular strategies are efficient, and it is the students who determined whether a particular answer was correct. I strived to use number talks to create an atmosphere where students felt safe to admit that their thinking had changed, either as a result of explaining how they solved the mathematical problem, or by observing another student's explanation.

As a student teacher, I used many strategies during number talks to ensure equity within the classroom and to make sure that all students have access to the learning. For example, I used the 'quiet thumbs' strategy to ensure that all students had time to work through the math problem before we began sharing strategies. I also used strategic assignment of competence to build lower status students' self efficacy and sense of mathematical ability.

Number talks are an excellent vehicle for examining the role of teacher talk in supporting student autonomy because number talks are a highly verbal instructional method that is built upon a series of teacher-student, and student-student interactions. Teachers' words are used to frame both the activity and students' contributions. By developing my usage of verbal moves from neutral to autonomy-supportive, I expected to see a corresponding shift in how engaged students are and the overall classroom environment. I typically used a fairly limited range of verbal moves during number talks (examples include "that's a very efficient/interesting strategy", "can you explain that strategy in your own words?") that tended to be either neutral towards, or supportive of, student autonomy, and leave room for students to evaluate strategies. I also worked in statements that built students' understanding of intelligence as a mutable quality that is dependent on effort and practice, rather than innate ability. I feel that these types of statements allowed students to develop multiple strategies, without concern for my evaluation, and shifted the responsibility of determining the value of a particular strategy to the students. Students learned that they can discover mathematical knowledge for themselves, and that teachers are not the sole arbiters of knowledge. In addition to this greater level of autonomy, students also built a broader and more flexible definition of what it means to do math, and thus what it means to be good at math.

In this research project, my use of language that supports students' incremental theory and intelligence increased in both quality and quantity over time as I become a more skilled educator. Additionally, research shows that it is helpful to introduce more autonomy for students as they develop the skills necessary to operate in an environment with greater freedom and responsibility (Leinhardt, Weidman, & Hammond, 1987). During the course of the action research project, I was be able to reflect on my instructional methods and incorporate what I learned from observing the class to improve my methods and adapt my study to my classroom.

Number talks, the focus of my study, were introduced on the first day of school, and remained an element of instruction during the entire study period. Number talks were first introduced with a minimal amount of autonomy-supportive language, to purposely introduce students into the structure and build students' skills and responsibility necessary for the incorporation of greater autonomy later in the school term. Typically, there were two to three number talks per week, and these were used either to introduce a new concept or to open a mathematical lesson.

Data Collection

This research project is a qualitative action research project in which I am a teacher-researcher. I collected the data during the ten-week period during which I student-taught at Green Creek Elementary during the fall of 2014. Data collection began with planning the first number talk and was completed by the end of student-teaching. Three types of data were collected: student post-number talk reflections and surveys, video and transcriptions, and a teaching log.

The first type of data were surveys collected from students after each number talk. The surveys were designed to collect information on how engaged students were during the number talk, their own assessment of their learning as a result of the number talk, and their assessment of their own knowledge and mathematical ability. By analyzing students' assessments of their own engagement, learning, and knowledge I was able to gain a sense of the impact of the introduction of autonomy-supportive language on students' sense of autonomy and their theory of intelligence. These were also useful as they are the students' own perceptions of their own engagement, and gave a sense of their internal state that may not have been accessible via other data sources. This allowed comparison between my own observations of their engagement and their own perceptions. Finally, by collecting students' evaluations of their learning, I was able to address gaps in understanding and better support the learning of the students in my classroom. These student reflections also allowed me to track students' learning and engagement over time, and provide individual data on each student These reflections were analyzed daily to provide feedback for my own day to day instruction, as well as to guide future lessons and identify students who would benefit from additional instruction. This data was used to adjust and fine tune lessons in order to create a more positive leaning environment. Each week during the duration of my research project, I briefly read through these reflections in order to collect information that would aid me in improving my practice as an educator. After the research period concluded, I read through students' responses in two manners. The first reading looked for general patterns in responses, and I created response codes to fit the data that arose over time. The second reading looked for patterns and trends in codes as the study progressed.

The second type of data were video recordings of several number talks that I gave during the course of the research project, approximately two to three number talks per week during the coarse of the research project. This data allowed me to observe myself, the actual words and tone of voice I used, my students, and my students' outward manifestations of engagement and interest after teaching was completed, when I had time to analyze the lesson in greater depth. This source of data was very useful because it gave me an opportunity to observe my interactions with students, as well as student-student interactions, and how these interactions created the tone of the classroom and affect individual students. It is also useful because it allowed me to focus on students and their state of engagement with a lot more detail than could be managed while actively teaching. This data source, when combined with the student reflections, also allowed comparison of students' own perceptions of engagement and my own observations of their engagement.

During the analysis phase of the project, after teaching had concluded, I watched and encoded the videos using descriptive terms for the situations and interactions that they captured. As the analysis progressed and I developed a more nuanced lens through which to view my practice, I reviewed the videos and developed more specific and useful codes. Over the course of the study, I looked for patterns of interactions and their effect on autonomy and engagement within the classroom.

The third type of data collected were my teaching log entries. This log included my thought process as I planned lessons, lesson plans, my objectives for my lessons, my expectations, quick notes taken while teaching to review with the video, post-teaching reflections, the methods I used while teaching, and the observations I took of the classroom and my students. This log was continued during the analysis period, to record my observations, ideas, and any questions that arose. Using the log, I was able to compare data from the video and student reflections, note trends over time, and record ideas and changes in my teaching and the classroom environment. This is an important data source because it is a record of how my understanding and methodology progressed over the course of the study period.

Data Analysis

Data were analyzed on an ongoing basis during the course of this research in order to incorporate new knowledge and build my ability as an educator. After the student-teaching phase concluded I analyzed my data in a deeper and more focused manner. Student reflections, video recordings, and my teaching log were analyzed and coded to identify common themes and concepts on a weekly basis throughout the research period. Each of these provided a different lens on students' perceptions and reactions to autonomy-supportive teacher talk, as well as how autonomy support altered the learning environment and students' relationship to the learning task. By carefully analyzing data from these sources, I captured information that allowed analysis of what happens when a teacher uses autonomy-supportive language in the classroom.

Each type of data was reviewed, looking for patterns between teacher talk, classroom interactions, and student engagement. Additionally, codes were developed for interactions and responses and applied to all of the data sources. This allowed the identification of patterns and interactions that were passed by or invisible during the school day.

Each number talk was videotaped, and then viewed after school hours to provide timely information for my instructional practice. Additionally, I looked for patterns between students' reflections and their activity and interactions in the videos to improve my methods of instruction. During the analysis phase of this project, I took notes of key occurrences and interactions, with time stamps, in a journal in order to compare this data source with other collected data. I looked for students' reactions to teacher talk, and their level of engagement and interest throughout the number talk. I reviewed the videos and the associated notes, and then transcribed the important sections of these videos. I then coded them as I viewed the videos, using terms to describe the interactions and reactions that I observed. The transcribed and encoded videos were then viewed again, in order to identify patterns that were not noticeable in real time or on the first viewing. This allowed me to ensure that I captured information as it emerges, and enabled the identification of important data. Throughout the analysis period I recorded the patterns, questions, and observations that emerged from the review of the videos and student reflections. While I used information from the data I collected to shape and improve my teaching in the future, I delayed analysis until teaching had concluded, in order to delve deeply into the data, to uncover shifting trends and elements that deserve further inquiry. I also used my teaching log to record my ideas, questions, concerns, and observations throughout the research project. At the end of my period of student-teaching, I incorporated the knowledge I had gained over the course of student-teaching and used the codes that emerged to transcribe and encode all of my data sources.

Statement of Limits of Conclusions

One of the challenges of this study was learning how to support students in learning that was more autonomous and required more responsibility from students as a beginning student-teacher. At times, I introduced the next step of autonomy too quickly, accidentally causing confusion and floundering among my students. As a first-time student teacher, I lacked the foundation of experience that would have allowed me to more effectively teach and engage my students.

Additionally, I was not able to increase student autonomy as quickly as I had expected because I was developing my ability to manage a classroom while the study period progressed. Over time I became more skilled at providing differentiation, however, some students persistently stated that they were bored throughout the number talks. With additional time in my student-teaching, I would have been able to build a stronger foundation of experience and skill, and would have been more able to consistently implement the methods of autonomy support that I had intended.

While this study was strengthened by the detail, quality, and quantity of the data collected, its transferability to other classrooms is hampered due to the specificity of focus and participants. This study was specifically tailored to culture and situation of Green Creek Elementary, and other teacher-researchers will need to alter the design to fit into their own situations. Another limitation is the short duration of the study period. The study took place over a total of ten weeks, which only offers a narrow window to observe interactions and shifts that occur as a result of the research project. Therefore, the results of this project are most applicable to the purpose of improving my own practice, and may be of note to other beginning teachers in very similar settings. Further, it is important to note that as students learn, they likely become better at the task. This makes it difficult to attribute improvement to the changes that teachers implement rather than increased skill on the part of the students.

CHAPTER 3—FINDINGS

As stated in the literature review, teachers, particularly beginning teachers, need to focus on autonomy in order to support autonomy in their classrooms, and it must be included explicitly in their lesson plans and their communication with students. This action-research project examined the relationship between attempts to support student autonomy and student engagement in the context of number talks. As the research has shown (Jang, Reeve, & Deci, 2010), I found it necessary to develop routines and structures before I was able to increase autonomy support in the classroom. Developing these routines and structures was challenging, as I was a student-teacher lacking previous experience. I found that it was difficult to devote the time and effort needed to consistently create truly autonomy-supportive lessons during my first quarter of student-teaching. As I analyzed my data, four main findings emerged. First, I found that focused teacher preparation is key to the inclusion of autonomy-supportive instructional methods. Second, an open-ended questioning style is a powerful tool for increasing student engagement, autonomy, and participation. The third finding that emerged is that student engagement and autonomy-supportive teacher behaviors increased over time. The fourth finding I found showed that a semi-random method of selecting students to respond lead to greater and more even participation.

Finding 1: Teacher Preparation Key to Autonomy Support

Throughout my student-teaching experience, I kept a teaching log-book in which I recorded my lesson planning and post-teaching reflections. I found that towards the beginning of the school year, I struggled to introduce autonomy-supportive elements into my math lessons because I had difficulty maintaining students' engagement and I had not yet built the classroom management routines necessary to support more autonomous learning. Here is an example of an entry from my teaching log-book during this time:

> I haven't been able to introduce much autonomy support or really get going on the number talks because my classroom management is very rough, and because I need to focus on a single focus in each lesson and streamlining my lessons. I see in my data myself saying again and again that I need to do better on CM, and being distracted by students not being engaged, and worrying about surface level solutions to that problem.

During this period, I was focused particularly on establishing a norm of respect for the speaker, whether the speaker was a teacher or a student, laying the foundation for respectful sharing of student ideas and discussion later in the study period. My log-book also highlights that I felt that my lessons were too broad and that my students were not focused or engaged with the lesson. During this time period, I often commented on what I felt I needed to focus on in the next lesson; what follows is an example of one such commentary:

> Need to be more careful about who I call and when. Wait time was iffy, need to differentiate; maybe next time say "once you've found a strategy, share it with some one else who has also finished, quietly." Focus on:
>
> - engagement
> - who I'm calling on
> - respect for other students talking

As the quarter passed, I became more able to focus on supporting autonomy. Two of the core changes that I believe supported student autonomy were creating more focused lessons, and asking more open-ended questions while also pushing students to explain their ideas.

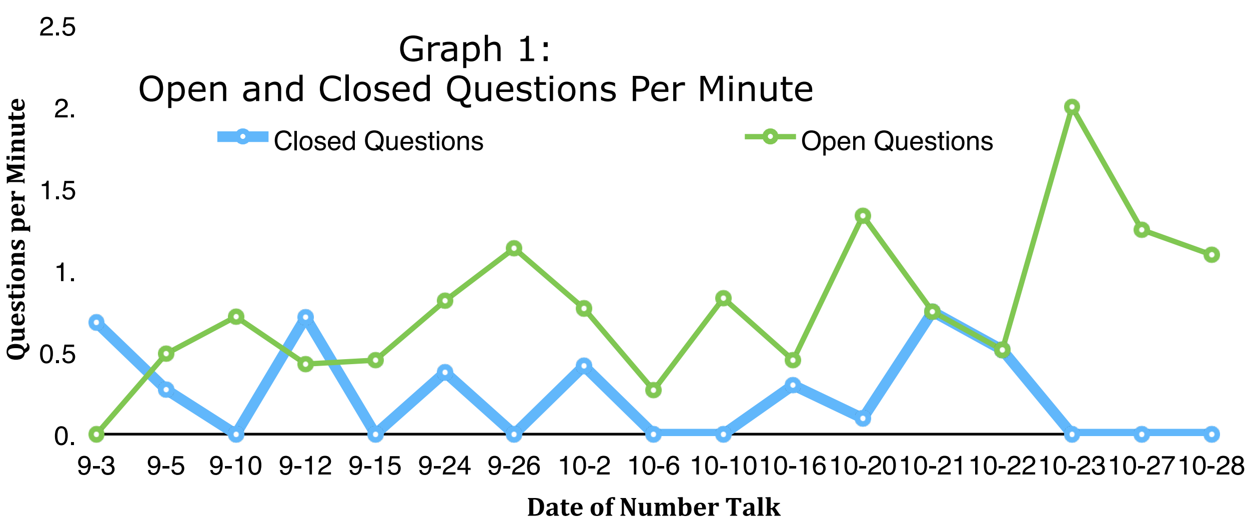
As evidenced in my log-book and lessons, at the beginning of my student-teaching period, I created lessons that had far too many problems and concepts. I think that I had difficulty in supporting students' autonomy and learning because I simply did not provide enough time for students to explore the math and explain their thinking. Because my lessons were too full, I ended up explaining concepts and asking more closed questions, rather than creating opportunities for students to explore and develop their own understandings. As I became more focused in my lessons, I was able to incorporate more wait time, more open-ended questions, and was able to shift towards having the students explain mathematical concepts, rather than taking time out of the lesson to lecture. I also began to focus more intently on students' ways of thinking about math, and how to better engage students with low self-efficacy. The entry from the 24th of October exemplifies this shift:

> Used quick images with groups of 7s. Definitely going to do it again, it was so cool to see how students were coming up with a ridiculous array of how to count. Part of what worked so well is that this was a novel mathematical task, so students had not already decided whether they were good or not at it, and probably some of them did not think that it actually counted as 'math'. I had some really great contributions by students that typically are not eager to share their math thinking.

Even with these improvements, I recognized that I had not been able to implement all of the elements of a number talk consistently. For example, I was rarely able to have a student explain or expand upon another student's answer. I believe that as I become more practiced as a teacher, and am more able to quickly imbed routine and structure, I will be more able to incorporate these elements in future classes. I learned that in order to support autonomy, I need to create time in my lessons so that students can develop and explain their understanding, and try multiple strategies for a mathematical problem.

Finding 2: Open-Ended Questions as a Means to Elicit Mathematical Thinking

One of the practices I found most useful was purposely shifting from closed to open-ended questions. Open-ended questions were those that didn't ask for simple yes or no, or were phrased to elicit a simple solution. Open-ended questions instead asked students to show how they solved a problem, or to explain their mathematical understanding. Through my analysis of the videos, I was able to track how many open-ended and closed questions per minute I asked during each number talk, as shown on Graph 1, below.



Graph 1: Number of open and closed questions per minute for each recorded number talk.

Clearly, there is a lot of variability. However, it can be seen that with time, open-ended questions became much more frequent, and closed questions did become more infrequent, especially towards the end of the study period. When I started using more open-ended questions, I saw an increase in how many students were able to share their ideas, increased opportunities for students to share their strategies, and more students working out solutions for themselves. I also saw an increase in students adopting the strategies that other students had shared on the board when I reviewed the videos. Asking open-ended questions is key to supporting student autonomy because students are offered opportunities to share and develop their thinking, and also begin to take more responsibility for explaining the mathematical concepts and determining the correct answer. This is an example of a move used to push students to explain their mathematical reasoning, which is a form of autonomy support (Reeve & Jang, 2006). At the beginning of my student-teaching period, I typically asked a student for an answer or strategy, and then explained the mathematical concepts rather than encouraging students to explain to their peers. An example interaction is shown below, from the 5th of September, a date early in the period, which also happened to have more open-ended than closed questions:

> Teacher: Alright, so it looks like people are ready. Who wants to share? Alright, Petra has a number sentence, and another way to solve it. She has four rows so she put 4 here, and 2 in each row, and she put 2 here, and she figured out that it was eight! Did someone else do it another way? (Holds up another student's work) Alright, so he has 2 x 4 = 8. So one of the things we're working on is the number of rows is the first number- so how many rows are there?
>
> Class: 4.
>
> Teacher: Right. So how many are in each row?
>
> Class: 2.
>
> Teacher: Right. So if we have a picture like this, what we want you to write is 4 x 2 = 8. Alright (gesturing towards students showing their work), you've got it, you've got it. Are you guys ready for the next one?
>
> Class: Yes.

Teacher: Erase your boards!

While technically I'm asking students an open-ended question here by asking them to show me how they solved it, I am doing all of the talking and all of the explaining. The expectation for students to explain their own thinking is not present in this dialog, and students were not offered the chance to speak for their reasoning. There is clearly one expected correct answer for each question, and the language is not autonomy-supportive. As my student-teaching experience continued, I asked more authentic open-ended questions that actually encouraged students to share their understanding. This can be observed in a conversation from the 21st of October, a day later in the study period when I asked an equal number of open-ended and closed questions. This conversation shows how later in my teaching, I matched closed questions to open-ended questions, by first asking for solutions and then asking students to explain their thinking:

Teacher: Here's our first problem. I want you to solve it in your head, and show me a quiet thumb when you've figured it out… Alright, Alberto, what do you think?

Alberto: Can I show you?

Teacher: You can tell me. I'm going to get your answers first.

Alberto: I think like four 9 + 9 is 18. Then what's 18 + 18?

Teacher: Mmm-hmm. And then what is that?

Alberto: It is, it equals, 8 + 8 is 16, so it's 36.

Teacher: So you think it's 36. So go like this if you also think it's 36 (makes ASL sign for 'same'). Does anyone think differently? (Makes ASL sign for different) So we all agree?

Class: Yea- no, Jordan doesn't.

Teacher: Jordan, what do you think?

Jordan: 34?

Teacher: Why do you think 34?

Jordan:…

Burt: You'd have to have two 8s and two 9s…

Jordan: Oh yeah…

Teacher: Alright, so let's look at the next one. 9 x 8. Ok, let's see who's got it? Linus?

Linus: 72.

Teacher: You think 72 …Linus thinks 72, (teacher writes on board) any other ideas?

Petra: I think 50.

Teacher: You think 50. (writes on board)

Class: Whaaaat.

Petra: No I think 60.

Class: Whaaat.

Teacher: Ok, turn your voices off. Any other ideas? Albert?

Albert: 72.

Teacher: Alright so you think the same as Linus?

Albert: yeah

Teacher: Alright, Linus, can you just tell me how you solved this problem?

Linus: Um, I just um, counted by 9s, eight times. I do that all the time, 9, 18, 27, 36, 45, 54, 63, 72.

Class: Bravo, bravo!

Teacher: Petra, how did you do it?

Petra: I did it because I knew that four 9s is 36, so I added four 9s.

Teacher: So you knew four 9s is 36 (teacher writes on board),

Petra: And I added four more 9s to that.

Teacher: Oh, so she did 9 x 4 What's 9 x 4 again?

Petra and class: 36.

Teacher: So, what's 36 plus 36?

Wilda: 6 + 6 is 12, so…

Petra: Oh, 72.

In comparing these two samples, we can observe a number of differences. Perhaps most striking is how much talking I did in the first sample, and how little time was devoted to students sharing their own thinking. In the second sample, I'm still talking a lot, but a major difference is that I'm confirming what the students are saying, and having them explain how they figured it out, while I wrote down their reasoning on the whiteboard. I am not giving solutions, or funneling students towards a particular answer. In this way, students are giving far more complex answers and the whole class is interacting more with the mathematical concepts. My final example, from the 27th of October, shows how students started developing more complex strategies and were confidently determining the solution to problems without much support from the teacher.

Teacher: Alright, are you guys ready for the next one? One, two, three (displays image of three sets of six dots on the projector, and then removes after three seconds)! Oh, I see a lot—I'm going to pull a stick. Lisa! What did you see?

Lisa: I saw, I saw three 6s,

Teacher: Three 6s…

Lisa: And then I counted them by counting 2, 4, 6, 8, 10, 12, 14, 16, 18. (Lisa walks up the to board and demonstrates how she counted the dots.)

Teacher: So you counted by 2s the whole way down (Draws circles around the pairs of dots Lisa pointed at.)

Lisa: Yeah.

Teacher: Alright, let me see who's next… (Draws stick) Oliver! How did you do it?

Oliver: Um, I counted by 6s.

Teacher: Ok, you counted by sixes.

Oliver: I counted by sixes in my mind. (Oliver walks up to board and gestures at the groups of six he saw)

Class: He stole my idea!

Teacher: Alright. (Draws circles around the 6s that Oliver indicated) Who had a different way than these two? Petra.

Petra: I did 6 x 3.

Teacher: You did 6 x 3. (Writes out 6 x 3 on the board) So she knew—

Petra: 6 x 3 = 18. Each three rows down there, I counted six rows.

Teacher: Alright, Cate?

Cate: I automatically knew that 6 + 6 is 12, + 6 = 18.

Teacher: Oh, nice. So she knew that 6 x 2 = 12, and then she added six more and got 18 (Records Cate's idea on the board). Are you guys ready for the next one?

Class: Yes! No!

Teacher: Ok, I'm going to draw one more stick—Alvin.

Alvin: Yes!

Teacher: So, what did you do?

Alvin: I actually did 2 x 9.

Teacher: You did 2 x 9? Show us how you thought.

Alvin: Because I know that, because I also counted by 3s to get the answer (shows on board) 3, 6, 9; 3, 6, 9. So I did 3, 6, 9, so 9 (gestures, cutting the middle set of 6 in half), so one 9, and these are the other 9. So there are two 9s in all.

Teacher: So 9 x 2 (draws circles around the 2 groups Alvin indicated). So you guys are coming up with a lot of strategies.

This final transcript shows that by the end of the study period, my use of open-ended questions had increased dramatically, and had undergone a qualitative change. The excerpt from the 27th of October shows that students were taking responsibility for explaining and justifying their mathematical thinking. Indeed, in this example, students were eagerly walking up to the board to demonstrate their understanding without prompting. This stands in sharp contrast to the transcript from 5th of September, when I did not provide students opportunities to authentically explain their understandings.

Finding 3: Student Sense of Engagement Improved Over Time

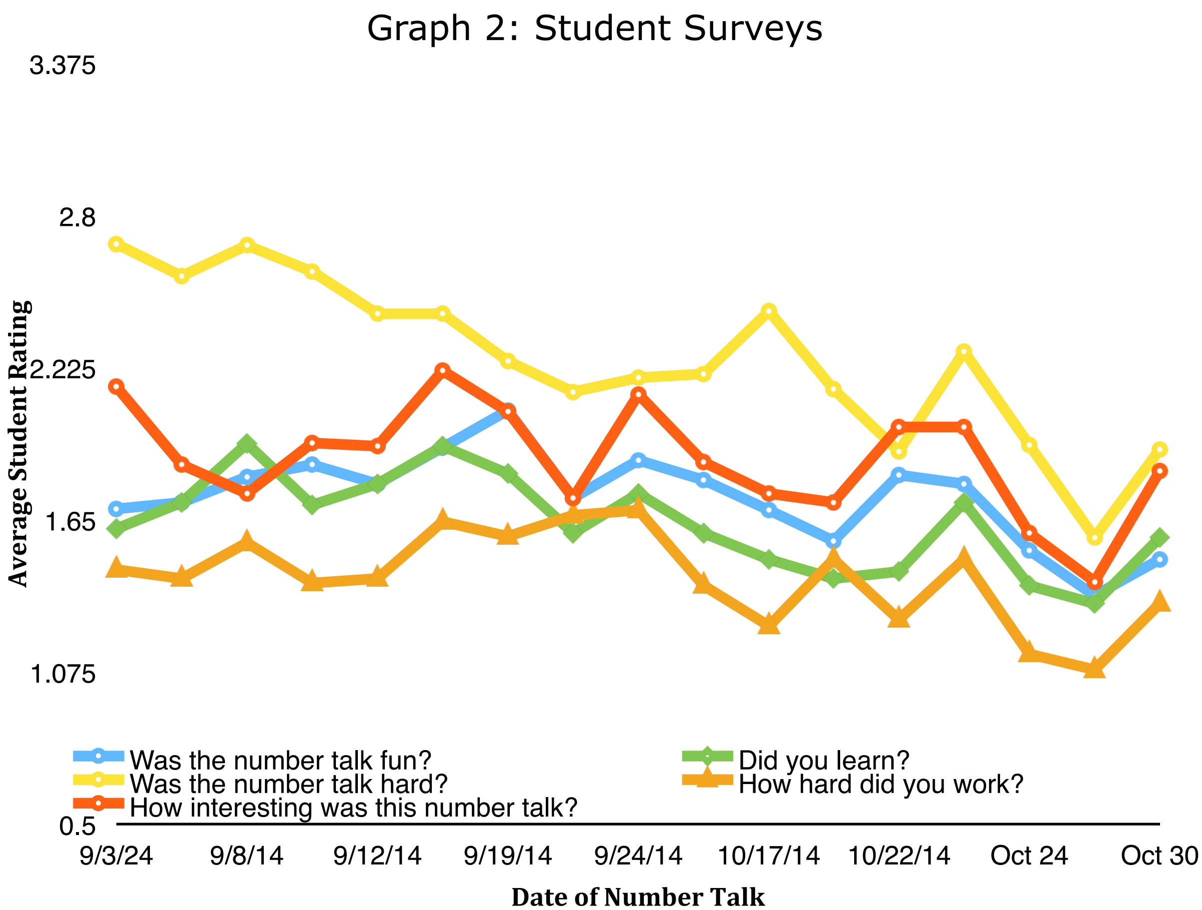
After number talks, students were given surveys, which had two components: a space for them to write about something they learned that day, and a portion that asked them to rate the number talk based on how fun it was, how much they learned, how hard the number talk was, how hard they worked, and how interesting the number talk was (See Appendix). As Reeve states, autonomy as an internal state cannot be measured directly, so engagement is used instead to track student autonomy (Reeve, 2012). An example of the survey lay out is shown below in Table 1.

Table 1

Today's number talk was:	Very fun	Kind of fun	Not fun
Today, I learned:	a lot	a little	nothing
Today's number talk was:	Hard	a little hard	Easy
Today, I worked:	Hard	a little	not at all
The number talk today was:	really interesting	somewhat interesting	boring

Table 1: Example of student survey.

For my analysis, I assigned a numerical value of one to responses in the first column, two in the second column, and three in the third column. During analysis, it was discovered that a few students had always circled the far left column. As I was specifically looking at variation in students' responses, these results were excluded from the analysis for the class. It should be noted that one of these three students was always pulled out of the class at the beginning of the math class, and returned just in time to take the survey. The other two, upon review of the videos, were always quite involved with the number talk and eager to offer their ideas and strategies to the group. Therefore, I think their scores are not representative of their actual engagement or sense of autonomy. My first step of analysis was to average the remaining responses to each of the prompts over the course of my study period. I choose to look at the ratings provided by students who were present throughout the study period, because I found that students often had individual patterns of ratings and I didn't want there to be an artificial change in the average score due to students leaving the classroom, rather than an actual change in how my number talks were perceived by the class as a whole. Graph 2 shows this data.



Graph 2: Student ratings of number talks throughout the study period.

One interesting result is that the perceived level of difficulty increased dramatically during the quarter, while the rest of the measures increase at a much slower pace. It should be noticed that as number talks became more challenging, students did not disengage, but rather continued to feel that they were interesting and fun. It also stands out that October 27th was rated as being the single most difficult number talk, along with being the day that students had the most fun, worked the hardest, learned the most, and found the number talk the most interesting.

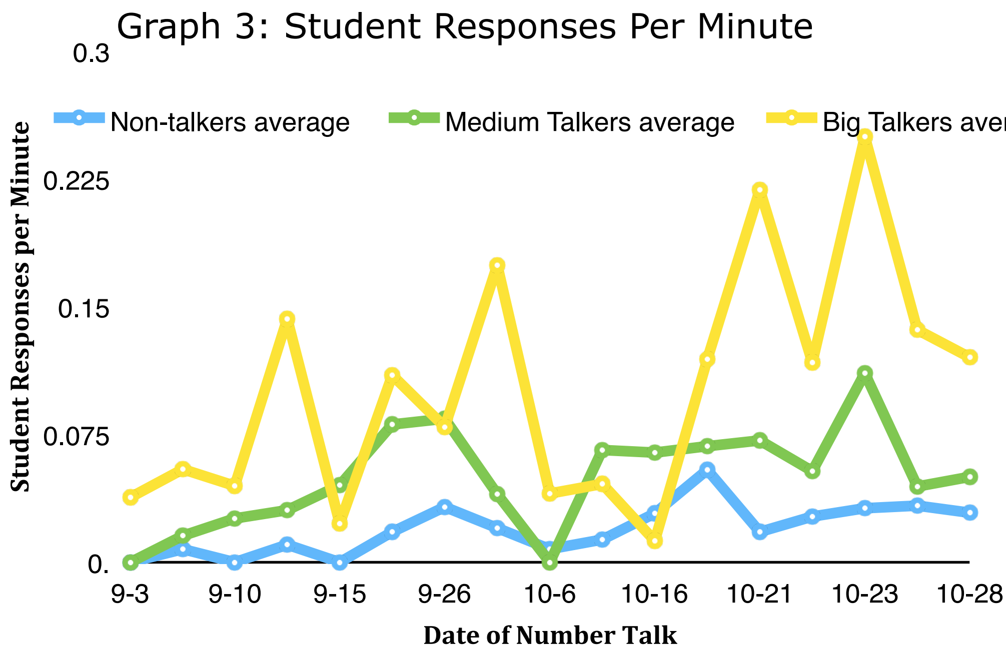
Because this lesson was rated so well, I wanted to find out more about what was different about the lesson. It turns out that on the 24th, I had introduced a new type of number talk, in which students are shown a number represented by dots, or a shape, or some other mathematical representation for a brief moment, and then they are asked what they saw. On the 24th, I did this with groups of 7s, going up to 4 x 7. On October 27th, the lesson rated the hardest by students, I did another quick images number talk with groups of 6s, and this time the arrays of dots went up to 9 x 6. As I recorded in my log-book in the following excerpt, this turned out to be an extremely useful method for both drawing out students who typically did not engage much, and for generating multiple strategies for solving a problem.

> Used quick images with groups of 7s. Definitely going to do it again, it was so cool to see how students were coming up with a ridiculous array of ways to count. Part of what I think worked so well is that this was a novel mathematical task, so students had not already decided whether they were good or not at it, and probably some of them did not think that it actually counted as 'math'. I had some really great contributions by students that typically are not eager to share their math thinking.

Students who typically were less engaged and less excited came to the forefront of the conversation, and it seems to have offered an entry point for many students who had struggled with math. Additionally, this method elicited solutions to multiplication problems that were far more complex than the problems we had recently been working with.

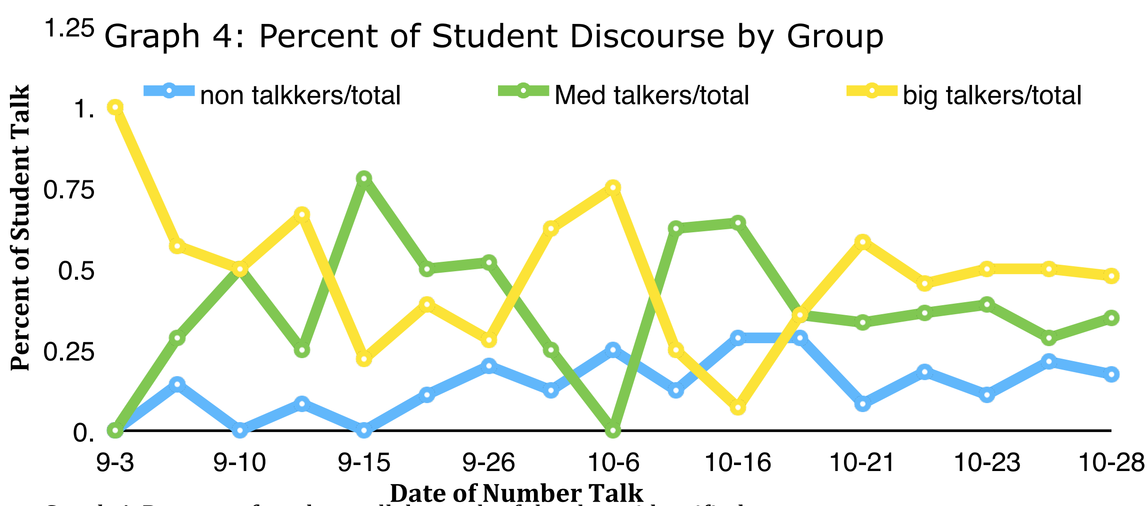
Finding 4: Semi-Random Selection of Student Responses

I found that using a semi-random method of selecting students to respond had several benefits that combined to increase student participation. When I reviewed the video from the 27th of October, I found that I had instituted using popsicle sticks to call on students for the first few students for each mathematical challenge. I had resorted to this as I found it difficult to call on students evenly over the course of a lesson, as a way to ensure fairness, and as a way to encourage everyone to be ready to share their answers. After pulling a few popsicle sticks and writing down the first few strategies, I then called for other strategies that had not yet been represented. I think that this worked well because the majority of the class usually had the same few strategies, while a handful of other students who were more comfortable with math found several. This method allowed me to randomly sample the class, which often lead to the most common strategies being represented. By then going back and asking for more strategies, I gave students who had more complex or unique understandings an opportunity to share their ideas as well, and thus increased the variety of responses represented. This method of using popsicle sticks and calling on students served as a way to ensure that everyone's ideas were heard and represented on the board, while also addressed concerns of fairness among the students. I after reviewing the video from the 27th, I also noticed that students who weren't often contributors to our number talks were eagerly signaling that they had an answer and were excited to share. This led me to consider the patterns of who was called on, and how often they were called on throughout the study period. In order to do this, I reviewed my videos, looking for instances when students had the opportunity to share their ideas and strategies, focusing on students that had been in the classroom for the entirety of the study period. After this was accomplished, I noticed that three main groups emerged from the data: students who averaged one response at least once per number talk (totaling four students), students who had an average of one response in at least half of the number talks (totaling seven students), and students who responded in less than half of the number talks (totaling an additional seven students), as can be seen in Graph 3.



Graph 3: Student response per minute for each recorded number talk.

As Graph 3 shows, the total number of student responses increased over the course of the study period. Moreover, as the study period progressed, the percentage of responses by the most talkative students fell, while the percentage of responses by the less talkative students rose, as shown Graph 4, below.



Graph 4: Percent of student talk by each of the three identified groups.

I think that these graphs provide evidence that I was improving my ability to call more evenly on students, and engage students who were, at the beginning of the study period, less willing to participate. It shows that the classroom discussions became less centered on the few confident students at the beginning of the period, as more students who had begun the study period with lower self-efficacy learned that it was safe to contribute their ideas and question. My evidence supports that an important factor leading to greater participation was the focus on mistakes as learning opportunities, because over time students became more willing to share their thinking, even when they weren't confident in their answers or had not completed the problem.

Implications and Recommendations:

These participants and this research project enabled me to build a greater understanding of how to support student autonomy and engagement in the classroom environment, as well as how to manage time and materials in a third grade classroom. Of primary importance, I learned from this experience that teachers must intentionally build in time for students to think, explore, and make mistakes. Further, I believe this is a much more efficient and rich use of learners' and teachers' time than lecturing, because students are actively engaging with math concepts and building deeper understandings than can be imparted by lectures.

From this research project, there are a few key elements of pedagogy that I will seek to include, not only in math, but in all content areas. Of these, I found that using open-ended questions served to dramatically increase student involvement and engagement, built student creativity and critical thinking, and led to a deeper understanding of concepts. I believe that the practice of asking open-ended questions can be extended past the time allotted to mathematics, and is equally practicable in the science classroom.

Another practice that I intend to carry with me into my future classrooms is that of calling on students in a semi-random manner. That is, while adjusting to the needs of the classroom, posing a question and selecting the first few respondents randomly, and then asking for students who have different, or more developed ideas. I saw that in my classroom this seemed to increase student engagement and enjoyment, address students' claims of fairness, and help engage students who were hesitant. By setting the expectation that anyone might be called, students learn that they must be ready with an idea, strategy, or question.

I observed that tied tightly to random calling is the practice of wait time. Combined, these two practices are powerful because they set the expectation for class-wide participation while also giving students the time necessary to think through academic challenges. Wait time was most effective when I told students that I was giving them time to think, told them to signal me when they had something to share, and waited until at least half the class had signaled me to begin taking responses.

Finally, I included an element of incremental theory every day of my student-teaching, and I believe that this helped students become more willing to share their ideas and tackle more difficult academic challenges. Each day, I told students that mistakes were how we learned, and that by working through our mistakes we can actually make ourselves smarter. By the end of my quarter of student-teaching, students were occasionally saying these words to me when they found an error in their thinking. Particularly for students with low self-efficacy, creating an environment in which it is not only safe to make mistakes, but actually welcomes mistakes as opportunities to learn, students are able to take greater learning risks and seemed more willing to put forth their ideas even when they were not entirely confident in their ideas. This allowed students to explore a greater variety of ideas, and often lead to deeper understandings of mathematical concepts. In my future classes, I will regularly come back to Dweck's work (Dweck, 2000), and incorporate explicit teaching of incremental theory at the beginning the year.

Taken together, I believe the practices that I implemented during my period of student-teaching will help to create the foundation of an autonomy-supportive and highly engaging classroom environment. I believe that these practices will create a teaching practice that is enjoyable and highly rewarding for myself as a teacher, and supportive, enjoyable, and rigorous for my students.

REFERENCES:

Alfi, O., Assor, A., & Katz, I. (2004). Learning to Allow Temporary Failure: Potential Benefits, Supportive Practices and Teacher Concerns. *Journal of Education for Teaching: International Research and Pedagogy, 30(1),* 27–41.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development*, *78*(1), 246–263.

Chambers, D. L. (2002). Putting research into practice in the elementary grades. Reston, VA: The National Council of Teachers of Mathematics, Inc.

Cohen, E. G., & Lotan, R. A. (1995). Producing equal-status interaction in the heterogeneous classroom. *American Educational Research Journal*, *32*(1), 99–120.

Deci, E. L., & Flaste, R. (1995). *Why we do what we do: The dynamics of personal autonomy.* GP Putnam’s Sons.

Dweck, C. S. (2000). *Self-theories: their role in motivation, personality, and development*. Philadelphia, PA: Psychology Press.

Hufferd-Ackles, K., Fuson, K. C., & Sherin, M. G. (2004). Describing levels and components of a math-talk learning community. *Journal for Research in Mathematics Education*, 81–116.

Jang, H. (2008). Supporting students’ motivation, engagement, and learning during an uninteresting activity. *Journal of Educational Psychology*, *100*(4), 798.

Jang, H., Reeve, J., & Deci, E. L. (2010). Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. *Journal of Educational Psychology*, *102*(3), 588.

Kazemi, E., & Stipek, D. (2001). Promoting conceptual thinking in four upper-elementary mathematics classrooms. Elementary School Journal, 102, 59-80.

Katz, I., & Assor, A. (2007). When Choice Motivates and When It Does Not. *Educational Psychology Review, 19(4),*

Konrad, M., Fowler, C. H., Walker, A. R., Test, D. W., & Wood, W. M. (2007). Effects of self-determination interventions on the academic skills of students with learning disabilities. *Learning Disability Quarterly*, *30*(2), 89–113.

Leinhardt, G., Weidman, C., & Hammond, K. M. (1987). Introduction and integration of classroom routines by expert teachers. Curriculum Inquiry, 135–176.

Morrone, A. S., Harkness, S. S., D'Ambrosio, B., & Caulfield, R. (2004). Patterns of instructional discourse that promote the perception of mastery goals in a social constructivist mathematics course. *Educational Studies in Mathematics*, *56*(1), 19–38.

Parrish, S. (2010). Number talks: helping children build mental math and computation strategies, grades K-5. Sausalito, CA: Math Solutions.

Raphael, L. M., Pressley, M., & Mohan, L. (2008). Engaging instruction in middle school classrooms: An observational study of nine teachers. *The Elementary School Journal*, *109*(1), 61–81.

Reeve, J. (2006). Teachers as facilitators: What autonomy-supportive teachers do and why their students benefit. *The Elementary School Journal*, *106*(3), 225–236.

Reeve, J. (2009). Why teachers adopt a controlling motivating style toward students and how they can become more autonomy supportive. *Educational Psychologist*, *44*(3), 159–175.

Reeve, J. (2012). A self-determination theory perspective on student engagement. In *Handbook of research on student engagement* (pp. 149–172).

Reeve, J., Bolt, E., & Cai, Y. (1999). Autonomy-supportive teachers: How they teach and motivate students. *Journal of Educational Psychology*, *91*(3), 537.

Reeve, J., Deci, E. L., & Ryan, R. M. (2004). Self-Determination Theory: A Dialectical Framework for Understanding Sociocultural Influences on Student Motivation. *Big Theories Revisited*, *4*, 31.

Reeve, J., & Jang, H. (2006). What teachers say and do to support students' autonomy during a learning activity. *Journal of Educational Psychology*, *98*(1), 209.

Stipek, D. J., Givvin, K. B., Salmon, J. M. and MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education, 1*7. 213-226.

Truxaw, M. P., & DeFranco, T. (2008). Mapping mathematics classroom discourse and its implications for models of teaching. *Journal for Research in Mathematics Education*, 489–525.

Wood, T., Williams, G., & McNeal, B. (2006). Children's mathematical thinking in different classroom cultures. *Journal for Research in Mathematics Education, 37*(3). 222-255.

Yackel, E., & Cobb, P. (1996). Sociomathematical Norms, Argumentation, and Autonomy in Mathematics. *Journal for Research in Mathematics Education*, *27*(4), 458–477.

Zull, J. E. (2002). *The art of changing the brain: enriching teaching by exploring the biology of learning*. Sterling, Va.: Stylus Pub.

APPENDIX:

Example Student Survey

1. What is an idea or a strategy that you learned today?

____

____

____

2. Circle the answer you think is true:

Today's number talk was:	Very fun	Kind of fun	Not fun
Today, I learned:	a lot	a little	nothing
Today's number talk was:	Hard	a little hard	Easy
Today, I worked	Hard	a little	not at all
The number talk today was:	really interesting	somewhat interesting	boring

3. Rate your understanding of the learning target:

I don't understand at all	I am beginning to understand	I understand and can solve problems without help	I understand and can teach others