Classroom Talk and Gender Differences in Mathematics

by

Elizabeth Kelly

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Abstract

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In response to the continuing problems that girls face in pursuing advanced mathematics in both their education and in careers that require strong mathematics skills, this project was designed to investigate how recent developments in classroom practice can affect traditionally gender differentiated attitudes and beliefs about learning mathematics. I hypothesized that the style of classroom talk used to engage children during math instruction influences their attitudes and beliefs about their own math abilities. Findings support the hypothesis that there is a relationship between students' participation in whole group discourse and gender differences in students' confidence in learning mathematics. In classes dominated by recitation styles of interaction (teacher-centered) girls scored significantly lower than boys in a measure of students' confidence in their ability to learn mathematics. In classrooms dominated by more student-centered discussions both girls and boys had strong confidence in their abilities to learn mathematics.

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Classroom talk and gender differences in mathematics

Introduction

Background to the problem

For nearly four decades researchers have reported that males outperform females on overall math achievement and outnumber females in attendance in higher mathematics education and in careers which rely on mathematical skills. However, many researchers agree that throughout elementary school girls are quite successful in mathematics, performing equal to and often better than, boys (Walkerdine, 1982; Walden & Walkerdine, 1985; Fennema, Carpenter & Lamon, 1991). Nevertheless, by the time they reach high school, girls' self esteem about their math abilities decreases, their anxiety about math increases, they score lower than boys on standardized math tests, and they are more likely than boys to avoid advanced math courses. By this time, female students also contend with an overwhelming social perception that they are not good at math.

Although girls are participating more in math and science than they were a decade ago (Bailey & Campbell, 1999) gender differences are still evident at an adult level when women workers are channeled into occupations that seem "appropriate" for women as continuations of roles females are expected to play in the wider society. For example, women represent over 80% of all cashiers, 98% of all secretaries, and 95% of all household workers (housekeepers, servants, child care workers, etc.) but only 19% of all physicians and 9% of all engineers (Ruth, 1995; NCES, 1997). Fewer than 14% of all doctoral degrees in mathematical, physical, and computer sciences and 6% of all engineering degrees have been awarded to women every year in the last decade (NSF, 1990; 1996). In their meta-analysis of gender studies in math performance Hyde, Fennema, Ryan, & Frost (1990) note that mathematics "is the critical filter" that prevents women from having access to higher paying, prestigious occupations. What changes for girls between their early success in elementary school and their avoidance of math as they get older?

Three issues frame my approach to this question. First, although there are no gender differences in overall performance in early grades, significant differences have been found between the ages of nine and twelve in specific domains: boys are favored for problem-solving tasks; and girls are favored for computation tasks (Hyde, 1997; Cohen & Blanc, 1996; Halpern, 1986; Stage, Kreinberg, Eccles, & Baker, 1985; Fennema & Carpenter, 1981; Fennema, 1974; Maccoby & Jacklin, 1974; Anastasi, 1958). Second, the rote learning of calculations has traditionally been the subject of early math instruction and is related to mechanical rather than meaningful math activity. Conversely, the learning involved with the problem solving of later math instruction is associated with meaningful rather than mechanical activities (Renkl & Helmke, 1992). Third, many researchers have found that girls' attitudes are the major barriers to their math achievement (Hyde, Fennema, Ryan, & Frost, 1990; Catsambis, 1994; Tobias, 1993; Javonovic, 2000.) Given these three issues, what is the relationship between gender differences in the learning activities for calculations and problem solving and gender differences in student confidence in the math classroom?

Prior Research

Girls' negative math experiences have been researched for years, with particular emphasis on social factors since the publication of the American Association of Women (AAUW) report "How schools shortchange girls" (Bailey, 1992). Since then schools, teachers, and parents have focused on ways that math education can be more gender equitable. A prominent theoretical motivation for these efforts describes how girls are conditioned to avoid math as a result of societal expectations and biases that contribute to a social construction of gender. Such expectations are mediated by adults' and peers' stereotypes and gender role beliefs (Lott, 1994; Tobias, 1993; Walkerdine, 1990).

Various findings also suggest girls experience math in a different and more negative way than boys. Girls have few female role models in math education and careers (Parsons, Adler, & Kaczala, 1982). Parents believe boys are better at math even when school performance is equal for boys and girls (Entwisle & Baker, 1983). Teachers encourage males in math classrooms more than they do females (Fox, Tobin, & Brody, 1979). Girls and boys perceive math as a male domain (Fennema & Sherman, 1979). Girls perceive math as less useful than boys do (Fox, Brody, & Tobin, 1980). Finally, a confounding stereotype perpetuates the belief that girls just don't do as well in math (Tobias, 1993).

Hyde, Fennema, & Lamon (1990) remarked that any general statement about behavioral gender differences (for example, "males outperform females") is misleading because it masks the complexity of the behavior. This complexity is evident in the variety of studies that report inconsistent findings of gender differences in mathematics education and that use "elusive evidence, with shifting categories and measures" (Halpern, 1986).

The juxtaposition of two meta-analyses published a year apart highlights these inconsistencies. On the one hand, Friedman (1989) reported on the variation in findings and the "controversial topic of sex differences in mathematical tasks" while on the other, Hyde, Fennema, & Lamon (1990) reported on the similarities among findings and the "consensus on the patterns of differences." It is difficult to reconcile all these findings when we are to believe both that "the magnitude of the gender difference has declined over the years [since 1974]" and that "the gap favoring males in higher level math skills is as wide now as it was thirty years ago" (Hyde et al, 1990, p. 139; Entwisle, Alexander, & Olson, 1994, p. 822).

Alternative Approaches

Walden and Walkerdine (1985) argue that there is a misconception in researchers' approach to girls' math experiences and that the issue of performance has more to do with activity in a social context and the social perceptions of that activity (i.e., "What is 'good' performance for girls?") than it does with girls' performance abilities. They are critical of the exclusive use of large-scale survey results to explain gender differences in performance and argue that the prevailing view of girls' overall failure in math performance is both inaccurate and misleading. Taking into account that, up until the age of eleven, girls are relatively successful in mathematics Walkerdine recommends a complete shift in the way that the problem of girls' performance is understood (1982).

Traditional explanations of girls' performance, such as those that rely upon sex differences in spatial ability or sex role stereotyping, have assumed performance is a simple and continuous phenomenon and are insufficient to account for girls' early success in mathematics. On the other hand, to treat the issue as one of discontinuity implies that girls' performance simply deteriorates over time. As a result, Walkerdine's work and her recommendations for further research focus on the importance of the period within girls' education in which it is presumed that the good performance in primary school is perceived as the relatively poor performance exhibited in secondary school (Walkerdine & Walden, 1985.) Girls' earlier "good" performance is based on the rote memorization and rule following of computation whereas the same performance later is less valued because it does not fit with the activities related to problem solving.

In a similar approach to gendered learning activity, Fennema & Peterson (1985) theorize that boys appear to outperform girls in problem solving because of learning behavior characterized by rule breaking, strong confidence, risk taking and discovery. Such activity is specifically linked to success in problem solving behavior and is contrasted by the procedure and rule-obeying behavior related to girls' success in earlier basic calculations. Certain rules and structures of classroom discourse afford the development of students' confidence to participate in such problem solving activities that support discovery, meaning making, and conceptual development.

Related to these differences for girls' activities and for how girls' performances are perceived between elementary and secondary school is the concept of "cognitive values" proposed by Goodnow (1990, 1996). These values stem from perceptions of what kinds of student behavior are regarded as "smart" or "intelligent". Goodnow recognizes these cognitive values as embedded in most Western achievement tasks, such as school performance and the assessment of performance.

Goodnow uses this concept of cognitive values to clarify two concepts of development -- *social context and* acculturation. These are, respectively, the prevailing ideas about what is optimal, acceptable performance and how one acquires the group's prevailing ideas. Goodnow notes that cognitive development therefore involves not only the acquisition of knowledge but also a set of ideas about what that knowledge is for and how to proceed in using it.

Threaded through these three approaches, (Walden & Walkerdine, 1985; Fenemma and Peterson, 1985; and Goodnow, 1996), is the notion that there are differences in how students are valued and that these differences are related to classroom activities and the contexts of learning. One difference is the use of language in the classroom to explore meaning and support concept development rather than to record and assess participation in "appropriate" classroom behavior. Also underlying this approach is the notion that students' attitudes about their learning, and their perceptions of self in the classroom context are connected to how they approach activity in particular classroom contexts.

Framework for Investigation

In this project I look at classroom discourse as the activity that underscores both the sociocultural context of students' learning and the development of their confidence as learners. I consider student gender differences as social constructions in this sociocultural context, rather than biological determinants. In the sociocultural context of learning, students' ideas about their abilities develop in relationship to interactions among peers and between students and teacher. The focus of this investigation is how the activity of math classroom discourse, particularly the whole group discourse that surrounds problem solving, relates to girls' confidence in their math abilities.

The works of the above three researchers helped to form the conceptual framework for this study: Walkerdine's work on girls' mathematics experiences in the transition from elementary to high school ("What is a good learner?"); Goodnow's work on cognitive values ("What is a smart learner?"); and Fennema's theory of gendered classroom learning behavior in problem solving ("What learner characteristics are necessary for certain kinds of math activities?"). The research implications suggested by these researchers point to a critical relationship between classroom activity and students' beliefs about themselves as math learners.

The underlying theoretical support for this research is in the Vygotskian and post Vygotskian tradition of understanding development as it occurs through activity and in a social and cultural context of learning. Since students' learning and their beliefs about their learning mirror the practices and attitudes of their classroom community it is important to understand the social and cultural shifts currently taking place in mathematics pedagogy in order to better understand differences in students' experiences.

These cultural and pedagogical shifts reflect a theoretical basis common to the approaches of Walkerdine, Goodnow, and Fennema and are found in certain ideas taken from cognitive developmental theory. These are that mathematics is thought of not as "facts to be stored" as in old conceptions of classroom teaching, rote memorization, and rule-following, but in terms of individual development in which mathematical concepts are developed through a process of individual discovery (Walkerdine, 1985.) In more recent changes of mathematics education this individual development takes place in a social context, through the process of shared understandings, acceptance of alternative strategies, and the student centered communication of the meanings that math activities have for the development of higher order concepts (NCTM, 1997). As the classroom context of activities and practices shifts so do the related attitudes and beliefs of students as math learners.

One approach to understanding how these contextual changes have consequence for students' acculturation and development of self confidence is in an analysis that can focus on the differences in classroom activity. The present project therefore looks to how the culture of a classroom affords certain types of discourse, and how this discourse and students' activity in the discourse relates to their own beliefs about themselves as learners.

Relevance of the project

This project focuses on a current, transitional state of math education and the pedagogical changes taking place in mathematics classroom discourse. The recent changes in mathematics teaching standards mandate more problem solving throughout elementary school and make it worthwhile to investigate the gender discrepancy between problem-solving and computation activities.

> Mathematical power is the ability to explore, conjecture, and reason logically; to solve non-routine problems; to communicate about and through mathematics...Mathematical power involves the development of personal self-confidence.... The math classroom is to operate like a community of people collaborating to make sense of mathematical ideas.

These excerpts from the National Council of Teachers of Mathematics emphasize the significance of communication and confidence in learning math (1989; 1991; 1995). Under the new standards, the teacher is to "orchestrate the discourse of the classroom" by means of questions such as 'How did you solve this problem?', 'Who did it another way?' 'Can you paraphrase what that student just explained?' This stress on language and talk about math is clearly evident in the central tenet of the new standards to monitor students' learning "through whole class discussions, clinical interviews, math journals, and performance assessments" (NCTM, 1989, 1991, 1993, 1995 as in Zalkower, 1997). Computation skills are not to be taught and assessed in isolation as in the old drill and practice approach, but in the course of engaging in, sharing, and discussing "worthwhile tasks" (NCTM, 1995).

According to these standards, students need to assess, interpret, and evaluate information rather than simply access it. This approach should result in classroom discourse that is less anecdotal reporting such as "What I did..." and more discursive and reflective, such as "What is significant about what we did...". Understanding this activity and meaning within the culture of the classroom, as something that develops differently for each classroom, and is guided to different degrees by each teacher and the students is the subject of the present research.

Using classrooms that share the same problem-solving approach to mathematics but which differ in how classroom talk is used, arranged, and controlled I measured the differences in student confidences.

Within this context of increased problem-solving activity and talk in the math classroom all students' opportunities to develop problem-solving skills and math confidence through sharing their strategies are also increased. To explore this confidence for girls it is necessary to consider this problem-solving activity and investigate it within a framework of class culture and talk. This study was therefore designed to examine the effect that the style of classroom talk in elementary school has on girls' confidence in their math learning.

Literature Review

Much attention has been focused in recent decades on the status of women and the educational and career opportunities available to them. The extent that societal beliefs and traditions influence educational practices and contribute to recorded and perceived gender differences has been depicted in many ways, including the nature of teacher-student and student-student interactions in the classroom. Research data indicate that gender differences in mathematics learning are often a reflection of prevailing circumstances rather than an indication of absolute differences between males and females (Leder, 1995).

This research project was designed to utilize the current changing circumstances of math instruction to investigate how changes in classroom discourse support girls' confidence in their ability to learn mathematics. The first topic, Gender differences in mathematics, reviews the perspectives on gender differences in mathematics performance, and student's attitudes about mathematics and their ability to learn it. This discussion leads to the hypothesis that confidence in mathematics develops differently for girls than for boys and is related to differences in their approaches to problem solving and to their different opportunities to become autonomous learners. This confidence is in turn related to students' choices in advanced math and related careers.

Under the second topic, Classroom Culture and Context, I explore the learning behaviors associated with problem solving and calculations. Here, I consider the importance of classroom discourse as an activity in the sociocultural nature of learning embraced by Vygotsky and the post Vygotskian activity theorists. Considering the current emphasis on student activity and talk in math learning I discuss classroom talk and its effect on students' beliefs and learning. I describe the different ways information is exchanged for girls and boys and discuss the findings that relate teachers' verbal behavior to girls' mathematics experience.

The third topic is a review of the issues related to the Current Historical Moment. This is a description of how mathematics instruction and pedagogy in general are changing historically and how these changes mean changes in the classroom culture hence changes in the activities, which shape girls' experience in math. I begin with a description of the various ways classroom talk and control of talk is changing. The classroom talk will be described as it is shifting from teacher-centered structures to more student-centered structures.

By tying these three topics together I clarify the relationship between girls choices and the classrooms activities in which their confidence develops. The relevance of the present study is situated in the current changes mandated by the

National Council of Mathematics Teachers toward more student-centered approaches to teaching mathematics.

Gender Differences in Mathematics

Research in girls' mathematics education increased in the 1970's partly as a result of the feminist inquiry into an inequitable gender distribution of career opportunities. Much research on gender differences in mathematics has focused on the social context of learning and development. From a feminist theoretical perspective factors include the stereotypes of gender roles, the expectations of parents, teachers, peers, and a lack of female role models in math as a science, in math teachers, and in math textbooks. In addition, research in the field of adolescent development has supported the premise that girls' self esteem in general declines in pre-adolescence and with it, not surprisingly, girls' self esteem in mathematics.

In 1992, the American Association of University Women report, How school's shortchange girls (Bailey, 1992) focused on the detrimental effects of classroom gender stereotypes for both girls and boys. Since then, schools, teachers, and parents have worked together to implement policies and programs that work for both boys and girls.

A considerable amount of research has been directed toward identifying correlates of mathematics performance and career choices in areas such as students' confidence (Gierl, 1995; Fennema & Peterson, 1985) and students' attributes of success and failure (Fennema et al, 1990; Eccles, 1985; Fennema &

Sherman, 1979). One provocative finding is that while early school grades and test scores predict later performance for boys, they do not for girls (Wentzel, 1988). This developmental gender difference has not been investigated as a function of instructional mediators that change from elementary to high school. Since early mathematics performance is strong for both genders in elementary school (Bailey, 1990; Hyde, et al, 1990a; Dossey, Mullis, Lindquist, & Chamber, 1988; Callahan & Clements, 1984; Fennema, 1974) it is worth investigating why there exists this gender difference in performance predictability. In other words, we can focus not just on the topic and content of math instruction but on the instruction itself.

Performance. The results of a series of meta-analyses of over one hundred studies conducted since the late 1960's report that, even after elementary school, gender differences in overall math performance are small. Yet, the assumption that males outperform females in mathematics persists (Cohen & Blanc, 1996; Fennema, Carpenter, & Lamon, 1991; Friedman 1989). Social stereotypes about girls'' abilities and girls' attitudes toward their own math abilities *regardless of performance* continue to be very negative in both academic and non-academic circles. Is it any wonder that girls' interest and participation in mathematics education declines or that they still do not pursue math related careers?

Findings that suggest that boys "excel in mathematical ability" (Maccoby and Jacklin, 1974) and "outperform girls in mathematical tests" (Halpern, 1986) have perpetuated a stereotype that girls are not as good as boys at math or that girls "can't do math." A disturbing paradox emerges from this literature when one compares these findings to the performance research that shows girls and boys equally capable of math achievement. Many research findings show girls perform just as well as and often better than boys, most notably in elementary school (Bailey, 1990; Hyde, Fennema & Lamon, 1990a; Dossey, Mullis, Lindquist, & Chamber, 1988; Callahan & Clements, 1984; Fennema, 1974).

Controversial findings in elementary school students' mathematics performance include: no gender differences before age ten (Entwisle, et al, 1994; Dossey, Mullis, Lindquist, & Chambers, 1988; Callahan & Clements, 1984; Siegel, 1968); differences favoring females (Kimball, 1989; Fennema, 1974); differences favoring boys in problem-solving tasks in the second grade, this difference decreasing in the fifth grade and disappearing by the eighth grade (Lewis & Hoover, 1986, as in Friedman, 1989). Findings from junior high school students include: small sex differences in favor of girls (Tsai & Walberg, 1979); small sex differences in favor of boys (Hilton & Berglund, 1974); no sex differences (Cicirelli, 1967; Connor & Serbin, 1985); substantial sex differences favoring boys in studies of gifted students (Benbow & Stanley, 1980; Weiner, 1984, as in Friedman, 1989); and favoring girls when school grades are used (Kimball, 1989).

It is important to keep in mind that computation tasks, while necessary as building blocks for higher mathematics activities, are not the primary focus of math instruction after elementary school when more abstract concepts, investigations, and problems solving are in the curriculum. Thus, when they leave elementary school, girls' excellence in computation activity is diminished by the presumption that calculations are already mastered. On the other hand, problem solving in mathematics instruction typically begins late in elementary school and has been more the domain of middle school.[1] Boys are said to be at an advantage in problem solving activities because they are encouraged both in and out of school to explore, experiment, trouble shoot, use resources, and to take risks (Burton, 1986; Carsambis, 1994; Entwisle, 1994; Meece, 1982). Thus, when they leave elementary school, boys are bolstered by the problem skills they've developed, but girls are left without the skills to transition to the new domain.

High school students' performance has been found more significantly gender differentiated. Performance findings have been reported that favor males (Benbow & Lubinski, 1993 ; Ramist & Arbeiter, 1986; Jones, Burton, & Davenport, 1984; Benbow & Stanley, 1980), especially in problem-solving performance (Carpenter, Lindquist, Mathews, & Silver, 1983). Two exceptions are that girls perform better than males on tests of computational skill (Stage, Kreinberg, Eccles, & Becker , 1985), and when grades instead of standardized scores are used (Kimball, 1989). This sample illustrates the conflicting results of studies comparing boys' and girls' performance on mathematical tasks, but as Halpern (1986) points out, the measures of performance (e.g., SAT scores, school

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[1] For a review of math curricula in the United States over the past century, see Zalkower, 1997.

grades) and tasks (e.g., algebraic problems, computations, problem-solving) are so varied that comparisons are deceiving.

Until recently, it was generally accepted that students from the same classrooms were taught in the same way, disregarding, for example, the reinforcement of sex-typed behavior or influences from teachers, parents and cultural artifacts (e.g., textbooks, problem narratives). One detrimental result of this assumption was the enormous setback made for girls and women when the popular media trumpeted the results of a John Hopkin's study directed by Benbow and Stanley (1980). The authors noted that "large sex differences" in mathematical aptitude were found in boys and girls who had essentially the same formal education experiences and got approximately the same grades in math in school (Benbow & Stanley, 1980.) Benbow and Stanley concluded that the differences must be innate, because the girls and boys had the same courses of instruction in school -- hence "environment was constant" (as cited in Kimball, 1989). The authors neglected to consider the socialization outside of school, the stigmatization of smart women as unfeminine, sex bias in the curriculum, and social messages encouraging women to "dumb themselves down" (Cohen & Blanc, 1996). Publication of their study resulted in a wave of press heralding the discovery of a "math gene" favoring men and announced by headlines such as these:

- Are Boys Better at Math? (The New York Times, 1980)
- Male Superiority (The Chronicle of Higher Education, 1980)

- Do Males Have a Math Gene? (Newsweek, 1980)
- Born Dumb (U.S. News, 1981)[2]

By far, the bulk of empirical studies, like that of Benbow & Stanley (1980), have used standardized test scores to report performance differences in favor of males, but with the use of meta-analyses feminist scholars have disputed these findings. Such disputes argue that gender differences are actually insignificant and that there are more similarities between boys and girls in math than there are differences (Kimball, 1996; Fennema & Lamon, 1991; Hyde, et al, 1989.)

Meta-analyses calculate effect sizes for each measurement of gender difference. The smallest possible effect size is zero, indicating that the two groups are identical on the particular measurement used. Generally, in studies of human differences, largest effect sizes are 2.0. For example, in one national study of math achievement (as cited in Hyde et al, 1991) an effect size of .23 favors males. This means that 56% of the males and 44% of the females were above the median score for the combined male and female samples - close to half of each group. In their examination of over 250 standardized test scores Hyde and colleagues (1991) found small effect sizes favoring males but when classroom grades were used females appeared to have the advantage. This contrast of higher classroom grades for girls and higher standardized scores for boys has been confirmed by others (Fennema & Leder, 1990; Kimball, 1989) but the results have never had the

[2] For more on media coverage of math and gender see Dusek & Hammer, 1995 ; Tobias, 1993.

attention of those that report a deficit for girls. Such attention perpetuates the myth that girls can not perform as well as boys in math.

Nevertheless, the stereotyped opinion that there are biological bases for differences in mathematics persists. Susan Faludi (1991), in theorizing the cultural phenomenon "backlash", interviewed philosophy professor Michael Levin who felt "compelled by conscience to present feminism as [he sees] it". He made the following key assertions (cited in Faludi, 1991, p. 296):

(1) "Women with successful careers sacrifice marriage and motherhood."

(2) "Sex roles are innate: women naturally prefer to cook and keep house, and men naturally don't."

(3) "Men are better at math."

Faludi notes that Dr. Levin, ironically, was interviewed at home while caring for his young children, a responsibility he shares with his wife -- who is a professor of philosophy of math.

Problem-Solving And Calculations. Gender differences in problem solving and calculations have been investigated with mixed results. For example, it has been suggested that one reason boys excel at problem solving in school is that they have more out of school opportunities to solve problems in their play and relationships (Kimball, 1989.) Others have suggested that math books present problem-solving exercises that are of particular relevance to boys. Problems are more likely to relate to industry or construction than to social events or helping a friend (Sweeney, 1994: Hunsley & Flessati, 1988). Johnson (1984) suggests that "other cognitive sex differences", such as male spatial ability, may be related to boys' problem-solving success, but offers no evidence to this end. Recent follow up reports to "How our schools shortchange girls" say that teachers continue to choose activities and contexts that interest boys more than girls (Javonovic, 2000).

The arguments that relate masculine and feminine behavior to the divergence between problem solving and calculations are more convincing. By the end of elementary school boys have developed more confidence in math problem-solving presumably because, compared to girls, they are more investigative, more curious, and more adventurous --- traits considered requisite to problem-solving behavior (Kimball, 1989; Mathematics Education Committee, 1986; Fennema & Peterson, 1985).

Girls, on the other hand, "set a great store in being neat and tidy" (Mathematics Education Committee, 1986) and tend to obey rules, and be easier to manage (Tobias, 1993; Fennema & Peterson, 1985) --- traits comparable to those used in following the steps to perform unambiguous basic arithmetic and calculations (Hyde, Fennema, & Lamon, 1990; Fennema & Peterson, 1985).

This perspective on girls' math experiences relates to Walkerdine's stance that at the heart of girls' math "problem" lies their own and others' perceptions of good behavior (Walkerdine & Walden, 1985). For example, Walkerdine (1985) investigated girls' math experiences as they relate to students' sense of identity, popularity, and their perceptions of what is a "good" student and a "likable" person. She found that girls link being good at their work with being nice, kind, and helpful.

Mechanical versus meaningful activity. The necessity to take into account subject matter (i.e., computation or problem-solving) in order to gain a deeper understanding of the teaching and learning processes was made clear by Carpenter & Peterson (1988) and was underscored by Renkl and Helmke's (1992) findings in their study of mechanical and meaningful math classroom activity. Renkl & Helmke studied the differences between classroom activities that emphasized rote, computational, mechanical learning and those that emphasized thoughtful, meaningful, metacognitive learning. They related "mechanical" activities to the development of basic computational skills, and "meaningful" activities to the development of problem solving competencies.

Teachers' ability to guide discussions about math as either mechanical or meaningful is related to the emphasis they place on product or process of student activity. In eliciting mechanical student responses about product, a teacher need do little more than initiate a recitation exchange, hear the student's response, and evaluate that response. As any one classroom culture develops its ideas and conventions about what is appropriate learning behavior, these teacher evaluations become the basis for what kinds of knowledge are valued in this context. On the other hand, a teacher who wants to emphasize the learning from students' meaningful activity needs to allow discussion about thoughts, strategies, and concepts. Students engaged in meaningful activity can not express these processes within the constraints of a recitation exchange. They need an open discussion centered on their thoughts about their activities.

Affect and students' math choices. This distinction between mechanical and meaningful work is further reflected in teachers' beliefs about students' math abilities and confidence. Walden and Walkerdine (1985) interviewed teachers and found relationships between student confidence and problem solving via the teachers' beliefs about student behavior. Teachers referred to the "most clever" students who could "break free" from following rules and from learning by rote. The top students could think abstractly; they were confident, and flexible. "They try an answer and if it is wrong...they try another approach. They have a certain confidence" (Walden & Walkerdine, 1985, p. 93).

The assessment of student confidence, interest, perseverance, and curiosity as they relate to learning and educational choices has been a developing concern in the last decade (National Council of Teachers in Mathematics 1989, 1995.) In response to this concern, there has been a growing interest in assessing affective, motivational, and attributional beliefs about learning mathematics in educational settings (Chipman, Krantz, & Silver 1992; Leder, 1990; Tobias, 1989; Entwisle et al, 1994)

Affect has typically been investigated as it relates to performance (Catsambis, 1994; Meese, Parsons, Kaczala, Goff, & Futterman, 1982), the behavior of teachers in the classroom (Sharkey, 1983; Shoenfeld, 1983), the significance of students' attributions of success and failure in math (Bempechat, 1996), and social stereotypes about girls' math ability (Bornholt, Goodnow, & Cooney, 1994; Tobias, 1993).

As a wide range of beliefs, feelings, and moods, affect in mathematics is most often represented in anxiety, confidence, frustration, and satisfaction (Macleod cited in Fennema, Carpenter & Lamon, 1991.) In the following quote, Gerald Goldin (1988) relates a progression of affective states to the activity of problem solving.

> In order for a problem to be felt as a problem, the problem solver must experience puzzlement and, quite possibly, as solution strategies are pursued, bewilderment. When a solution is finally hit upon, one experiences satisfaction, but if initial attempts are fruitless, frustration results. If [other approaches] are unsuccessful, the result can be anxiety or even despair, and a more urgent problem -- how to get out of an unbearable situation -- may supplant the original. When this happens, the problem solver may drop out, make a guess, or just mimic someone else's solution without understanding it. (As cited in Schifter & Fosnot, 1993, p. 74).

Psychological theories associate girls' math experiences with high math anxiety, negative beliefs about the usefulness of mathematics, and the attribution of math success to effort and math failure to ability. Boys' math experiences, on the other hand, are associated with high confidence in their math abilities, strong

positive beliefs about the usefulness of mathematical knowledge, and the attribution of math success to ability and failure to lack of effort - a direct contrast to girls' attributions (Aiken, 1976; Eccles, 1987; Bornholt, Goodnow, & Cooney, 1994; American Association of University Women, 1996).
Girls' negative associations to mathematics are one explanation for their avoidance of mathematics courses when given a choice (Tobias, 1993) but the development of such negative affect needs further understanding.

A more social perspective associates girls' feelings about their math ability with gender role expectations, perceptions, and biases. The following quote highlights the popular belief that girls experience some sort of decline in mathematics when they leave elementary school. It is from a recent announcement about yet another program to improve girls' participation in mathematics. The CEO of a technology corporation recently announced the sponsorship of a math mentor program for girls. "Our efforts were born out of the oft-cited research that shows that girls' participation in science and math in school nose-dives around the time they reach middle school age...." (Santo, 1997.) Like many others, this program seeks to improve girls' participation through mentoring and support, consistent with the view that girls lack role models in the field. In addition to the gender role model theory is the little research that theorizes on the causes of girl's choices and the developmental considerations to be made during earlier education experiences.

One such approach is found in Walkerdine's focus on the links between students' and teachers' gendered perceptions of student math performance. Walkerdine (1985) describes how girls link cleverness in math to good behavior in general --- "nice, helpful, and kind girls are good students." Ironically, a common theme from the teachers interviewed in Walkerdine's research is that the active, inquiring, rule-breaking child was a better student than was the counterpoised well behaved, passive, rule-following child. Walkerdine found that, in spite of the teachers' efforts to remain gender neutral and to resist gender stereotypes, the teachers mostly referred to the active and "better" learners as boys, and the passive ones as girls (Walkerdine, 1985.)

Other findings suggest that boys and girls are similarly anxious about math tasks and tests (Tobias, 1993). Nevertheless, boys have been found to have greater confidence in their math abilities, particularly in problem solving (Fennema & Leder, 1993). This problem-solving confidence has been related to boys activities in sports and play outside of school (Mathematical Education Committee Report, 1986; Walkerdine, 1990); to their stronger beliefs about math as a male domain (Fennema & Sherman, 1977; Tartre & Fennema, 1995; Thorndike, 1991; Rathbone, 1989); and to their stronger perceptions of math as useful (Bempechat, 1983; Cohen & Blanc, 1996). These findings support Fennema & Peterson's theory that links beliefs about ability with students' confidence and success in math. Girls' confidence is the key variable in predicting girls' math achievement and girls' participation in higher-level math courses (Fennema and Peterson, 1985).

Attributions of Success and Failure In Mathematics. Since the late 1970's, researchers have shifted their investigative focus from performance and "innate differences" to the influence of choice behavior on what female students do (Tobias, 1993; Eccles, 1985; 1987). Girls' choices are linked not only to what they perceive to be the value of mathematics, but to their expectations of how well they will do if they continue in math (Burton, 1986; Carsambis, 1994). Attribution theory gives some clues as to why even the girls "smartest in math" have little confidence in their math ability and seldom choose to pursue math related career paths (Tobias, 1993).

Until recently, little attention has been paid to girls' and women's self-related cognitions in mathematics and the sciences (Heller & Zeigler, 1996). Females underestimate their own talents in these domains and, from a motivational perspective, attribute their successes and failures in such a way as to further inhibit motivation. Boys and girls differ in how they explain their success and failures (Eccles, 1985). Girls tend to attribute their success to effort, whereas boys tend to attribute their success to ability. Conversely, girls attribute their failures to lack of ability, whereas boys attribute their failures to lack of effort (Tobias, 1993; Fennema et al, 1991; Eccles, 1985). The girls who attribute their math success to consistent effort, rather than ability, will have low expectations for future success because they perceive future courses will likely be even more demanding (Eccles, 1985).

This attribution of math success to effort rather than ability may explain why girls avoid pursuing math in higher education. Compared to boys, girls have lower perceptions of their ability[3] and lower expectations for success (Eccles; 1984; Entwisle et al, 1994). Even girls who perform well in mathematics do not gain, or do not maintain, confidence in their ability. For example, a survey of Barnard college students with high math scores on entrance exams indicated that their previous success in math had little to do with their choices for course registration or their career plans. It was their desire to avoid mathematics that primarily affected these choices (Chipman, Krantz, & Silver, 1992, cited in Tobias, 1993, p. 104).

Findings in support of these also come from cross-cultural research such as that of Stetsenko and colleagues who found that even girls with higher grades than boys never reported having stronger beliefs in their own talent. [4] Even though girls and boys showed similar ideas about what leads to academic success, girls were more biased in some contexts than others, suggesting that competence-related biases are rooted in culture-specific aspects of schools.

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[3] Studies in support of this finding include Deaux, 1976; Eccles, 1983; Fennema & Sherman, 1977; Frey & Ruble, 1987.

[4] In a cross cultural study of over 3,000 students in grade 2 to 6, boys and girls around the world were found to have very similar ideas about what leads to their academic success; where academic success was equal, boys and girls beliefs were also equal. However, when girls outperformed boys they did not have stronger beliefs in their own talent than did the boys -- despite equal beliefs about effort, luck, and teacher's help.

What is different for boys and girls that denies girls the pride, confidence, and self acclaimed credit for doing well in math, yet allows boys to take ownership of their math achievements? Eccles (1985, 1997) has investigated students' attitudes toward math and science specifically as they relate to classroom characteristics in the transition between elementary school and high school. She has found correlations between male and female students' negative attitudes toward math and large classroom size (numbers of students), low socio-economic status, and teachers' attitudes (Eccles, 1997). Although teacher- student interactions have been found to differ by gender, the broader scope of classroom activities has not been investigated as a context in which gender differences may develop.

Mathematics Instruction. Although student-teacher interactions, peer interactions, and textual references, have been investigated, the approach and activities of mathematics pedagogical style have not been related specifically to gender differences in learning math. Such an approach would entail an understanding of how classroom practice differs among teachers in their approach to math. Until recently[5], a full picture of math instructional practices has been methodologically difficult to collect. Edwards & Westgate (1987) argue that collection of dyadic and group interactions and reliable data has been difficult and intrusive until recent technological developments in recording equipment.

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[5] The TIMMS videotape classroom study is a recent exploratory research project on math instruction in eighth grade classrooms in the United States. Germany, and Japan (Stigler, et al. 1999).

In a review of research in mathematics education, Bell and colleagues (1983) investigated changes in students' attitudes as they relate to historical changes in math curricula and found that modern changes in the curriculum have not led to improved student attitudes about math. Echoing the implications for further research that result from many classroom observation studies, Bell and colleagues recommended that the nature of classroom activities be more closely looked at in order to understand their effects on students' attitudes and appreciation of the subject.

Until recently, there has been a dearth of studies that focus closely on day to day activities, although such investigations of classroom instructional practice have increased with the recent paradigm shift towards ethnographic methodologies. Fennema & Peterson (1985) took a closer look at daily activity in their work that relates girls' lack of confidence to the degree to which they control their own learning.

Fennema and Peterson's model of "autonomous learning behavior" describes how students who work independently and achieve success are naturally driven to continue even when tasks are difficult. This perseverance inevitably leads to success and self-confidence, and to reinforcement of the behavior, in this case the math activity or problem solving (Fennema & Peterson, 1985.) This model can be used to understand how girls' lower confidence in math is related to how they have not developed such learning behavior. Girls are taught <u>not</u> to be independent, nor to take risks, nor to want to be in control.

These girls give up on math as a subject worth pursuing, regardless of their performance. In related findings girls have been described as more concerned with how people think of them, more reluctant to approach problems that have more than one answer, less willing to speculate, and needing more feedback than boys as to how they are doing (Maccoby & Jacklin, 1974, cited in Tobias, 1993.) These behaviors also relate to the "good girl" behavior that Walkerdine uses to describe how, as girls move up in grade, teachers relate their passive behavior to poor learning behavior.

Subtle forms of gender bias still exist in classrooms despite teachers' best efforts towards "multicultural" and gender equitable practice. In recent observations in science classrooms, boys were called upon more than females, received more attention, were asked more complex questions, given more detailed instructions, encouraged more to take advanced science courses, and provided with more adequate role models (Bojesen, 1999.)

On the other hand, girls lacked the confidence to answer open-ended questions, mostly answered lower level questions, had work done for them, and paged through textbooks depicting male scientists as role models. By the time they reach the critical, attitude forming middle school years girls internalize their challenges in math and science, while teachers discourage them from pursuing these subjects through subtle forms of gender bias. The girls develop negative attitudes about math and science and pursue other avenues of interest. Boys, on the other hand, generally blame their challenges on external circumstances, and continue on to advanced classes in math and science (Bojesen, 1999).

Why are girls less willing than boys to take risks and control their learning? The answer to this question may be the underlying theoretical link between classroom practice and the decline in girls' math confidence that this project investigates. If girls' avoidance of math is linked to their non-autonomous learning behavior, then the nature of classroom activity, which fosters this behavior, must be addressed. The better we understand how school experiences and learning behavior foster negative achievement related beliefs and values and how they perpetuate gender stereotypes, the better able we will be to design school programs that will have a positive effect on children's development and life opportunities.

Ideas about what performance should be like. Much of the foundation for my interest in the relationship between achievement related beliefs and how children experience classroom talk is derived from Goodnow's (1990, 1996) concept of "cognitive values." As I mentioned earlier, Goodnow proposed that these values stem from differences in what are regarded as "smart" or "intelligent" actions. Although Goodnow's concept was developed from a need to account for differences among cultural groups in their scores on tests of intelligence, she recognized cognitive values as embedded in most Western achievement tasks, such as school performance and the assessment of performance. In this project, I consider the activity of math wrap-up discourse as a context for performance and assessment. In any one classroom this is a context with a reciprocal relationship to the classroom's culture, specified not only by discursive differences but also by the cognitive values of its participants --- the teacher and students.

The embeddedness of these values in most tasks led Goodnow to consider that cognitive values provide clarification of two concepts in the developmental literature, which she had considered "often amorphous." One of these is *social context* -- the prevailing ideas about optimal, tolerable, and unacceptable performances. The other is *acculturation* (or *enculturation*) -- the acquisition of the group's prevailing ideas. "In effect," Goodnow notes, "cognitive development could be regarded as involving the acquisition of knowledge but also a set of ideas about what one should use one's knowledge for and how the use should proceed." (1996, p.167.)

This perspective of social context and acculturation fits well with both Walkerdine's work on the devalued nature of girls' achievement as they get older (Walden & Walkerdine, 1985) and with the current interest to understand development in the context of classroom cultures (Cobb, 1997; Cole, 1999; Saxe, 1991). Combined, they describe the complex system within which students develop. This is a setting in which values, ideas, misperceptions, biases, and stereotypes about performance exist for every member. Traditionally, the teacher has had the strongest position from which to influence classroom culture through her cognitive values. The literature discussing teachers' influence and stereotypes is plentiful. However, since the current dynamics of classroom activity are changing so that instruction is less teacher-centered, what might also change are the levels of influence and the nature of the participants' cognitive values.

Classroom Culture and Context

Considering the historical and institutional changes taking place in math education, it is an opportune time to understand the social context of mathematics learning, the discourse in the classroom; and the mediating effects of both elements on students' attitudes toward math. My considerations of activity and context in this project are framed within theoretical assumptions of the social-historical and cultural perspectives that developed from the work of Vygotsky and those that followed him.

One way to think about classroom practice and talk is in terms of classroom culture and the concepts of "context" and "activity." The premise is that classroom cultures are most effectively studied in terms of the activities that constitute them and in relation to the institutional contexts that they in turn constitute. In the present inquiry, I discuss the classroom culture as it is constituted by math problem solving activities and the discourse that evolves from them, particularly those forms of discourse which are a component of the math lesson (i.e., the Math Congress, or wrap-up.)

Learning's Cultural Context Until relatively recently[6], dominant psychological theories of learning assumed that culture is irrelevant to the processes of learning. Following the Soviet school, cognitive development is thought to occur in the individual, not in isolation, but in an historical and social context and within the cultural makeup of a society (Wertsch, 1991; Scribner & Cole, 1981; Vygotsky, 1978; Luria, 1976).

This context has been elaborated to extend beyond cross-cultural bases for understanding learning and development to include the particular activities of cooperation and interaction (Wertsch, 1984), and the interdependence of present texts on historical ones (Bakhtin, 1981). Within these theoretical frameworks the activity of group discussions in a classroom exists as a dynamic system of negotiations toward shared meaning situated within institutional, cultural, and historical specificity of mental functioning (Wertsch, 1990). Such a sociocultural perspective emphasizes how individual efforts, interpersonal involvements, and culturally organized activities constitute each other (Rogoff, 1993). The unit of analysis therefore is a social interaction, so the focus of the present project is the talk in the classroom.

Bauersfeld & Cobb (1995) describe a student in this activity and context as an active creator "of ways of knowing", who learns by an "interactive construction" of mathematics meaning in a classroom culture. Analyses of this

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[6] Current discussions of classroom cultures rely heavily on debates about the most effective forms of classroom organization that occupied the originators of psychology and parallel arguments about the nature of culture that occupied the originators of anthropology and sociology (Bruner, 1996; Erickson, 1986 cited in Cole, 1999).

type of learning and development cannot focus exclusively on the individual, but must be derived from a unit of analysis that includes the social interactions of the students and the teacher, as is found in the works of Lave (1988) ; Newman Griffin, & Cole (1989) ; and Saxe (1991.) Social interactions such as these can not be understood without including classroom talk.

In the last decade, investigations of such social interactions have revealed strong differences in classroom practice. One result of these findings is an increased emphasis on understanding the ways that language is used in mathematics instruction (Stigler, 1997). Cobb (1997), for example, argued that classroom discourse could be so particular to a classroom's culture that almost any outside observer could differentiate between discussions in two neighboring classrooms using just a small sample of the classroom discourse. Regrettably, "nobody talks to teachers about how to talk to students" (Saxe, 1997). Thus, the research and theory in managing classroom discourse as pedagogical changes occur is small. As the discourse of the classroom is traditionally managed by the teacher, this activity and all the factors affected by and affecting it should be closely investigated and used in teacher training.

One factor for consideration is the way in which students' understanding develops in relation to others around them. Wertsch extended Vygotsky's notion of the social context of learning by exploring the relationship between the intermental and intramental (Wertsch, 1991). He argues that the intermental can only be studied and understood in light of the social and cultural context in which a specific intermental activity is embedded. Such activities are the settings in which individuals are participating in their own and others' understanding as they interact in the social world around them. O'Connor (1996) uses classroom group discussions to show how these contextual dimensions of social and cultural forms of organization shape the outcomes for intramental learning. O'Connor's analysis of the group discussion reveals the complexity facing the teacher in such a setting while she orchestrates the group's intermental functioning by orchestrating the language use.

The synthesis of intra- and interpsychological processes is currently understood through an activity theory perspective as "the transformation of goal-directed human activities extended and mediated by culturally generated and socially transmitted activities crystallized in cultural tools" (Stetsenko, 1999). The activity of classroom discourse, as culturally generated and socially transmitted, is the "germ-cell" of learning in the sociocultural context and is vulnerable to historical changes in the culture of instruction.

This relates to the present math learning situation if we consider current historical changes taking place in the social and cultural context of the math classroom. On the one hand, stereotypes of girls' deficits exist in a math classroom culture of traditional instructional activities and artifacts. These include gender bias in textual references; teacher bias in interactions; learning behavior support for boys in problem solving; a lack of female gender-role models; and the decreased value of certain performance (i.e., in calculations and rule following) as grade level increases. In this context, teachers approach mathematics as an absolute set of rules (Fennema, Carpenter, Lamon, 1991). Their primary reference for instruction is a formal sequence of mathematics, determined either by math textbooks and how their topics are organized. The teacher's role here is that of expert, to impart established information to the students.

On the other hand, current pedagogical changes in math education create a different, more student centered math classroom culture. This context is marked by more and earlier (grade level) problem solving, more classroom student-talk, fewer teacher determined interactions, and more student centered activity and discourse. The pedagogical changes are toward a more "constructivist" math classroom in which the focus of instruction develops from the students' socially mediated activity and their understanding rather than from perceived notions of a mathematics formal structure or sequence. The teacher's role in this context is not as math expert but as guide or facilitator. She or he seeks to understand how the student is thinking about math and in what direction he or she might next explore through math activity. In this context the talk about math activity and math ideas is about math meaning rather than about reports of math product.

This classroom discourse is described by constructivists who distinguish between "really talking" and didactic talk in which speakers' intentions are to hold forth rather than share ideas (Belencky et al, 1986). In didactic talk, participants may report experience but there is no attempt to work together to arrive at shared understanding. This distinction and its relationship to gender differences are discussed in more detail in the section below on classroom discourse.

Teachers' behavior and beliefs about mathematics. Classroom observations have revealed marked similarities in the ways that math is taught (Brophy & Good, 1986; Leder, 1990; Leinhardt & Putnam, 1987; Stodolsky, 19888). Most frequently, teacher exposition is followed by students' attempts at the work. In lower grades there may also be practice with manipulative materials before paper and pencil work. This apparent uniformity of procedure has shaped researchers' attempts to describe in-class activities, mainly through the use of unobtrusive observation schedules used to describe teachers' in class behaviors (Leder, 1995).

Studies have found small but consistent patterns of differences in teachers' behavior toward girls and boys. For example, teachers have been found to have more interaction with boys (Eccles & Blumenfeld, 1985; Serbin, O'Leary, Kent, & Tonick, 1973; Stake & Katz, 1982); and in assessing peer perceptions, both boys and girls perceive girls to be better behaved and to receive better teacher treatment (Kaminski & Sheridan, 1984, as in Stipek, 1992). Researchers have expressed concern that differential treatment, even where it appears to favor girls, could eventually render girls less effective in the more competitive and achievement-oriented environments of the upper grades and the work-place (Stipek, 1992).

This concern echoes the fundamental principles of: (1) Fennema and Peterson's autonomous-learner model as a precursors to success and achievement; (2) and Walkerdine's "good behavior - bad learner" theory. For example, girls get teacher reinforcement to stay together, and to be "quiet and well behaved" from early on in school but boys receive more positive attention and approval than girls when they engage in task relevant behavior (Serbin et al, 1973). Thus, girls are encouraged to stay put and to behave while boys are encouraged to explore and to take risks. Using the autonomous-learner behavior model, this teacher reinforcement relates to girls' confidence by discouraging the risk-taking behavior that leads to a girl's ownership of learning.

The American Association of University Women report "How schools shortchange girls" (Bailey, 1992) confirmed that negative stereotypes about girls and math still exist, especially in the classroom. Both male and female teachers ignore high-achieving girls more than any other group in the classroom. Teachers encourage boys to speak out, to follow through on ideas and to correct mistakes. On the other hand teachers have been found to complete their answers for girls, when there is any hesitation in response, explaining, "They [girls] know the answer anyway. They'll be alright" (Lott, 1994).

In the elementary grades, teachers tend to expect better performance from girls primarily because they are perceived to be easier to manage and more obedient (Dusek & Joseph, 1983, in Stipek). However, in the later grades, teachers perceive more masculine characteristics, such as independence and a challenging nature to be associated with intelligence (Benz, Pfeiffer, & Newman, 1981; Bernard, 1979). This switch in values could explain why girls' high grades in elementary school math are not predictive of math success in high school because the reinforced feminine behavior is no longer valued.

Differences in students' achievement and learning in problem solving and calculations have been related to teachers' pedagogical beliefs about mathematics (Peterson, Fennema, Carpenter, Loef, 1989). Compared to teachers with a less cognitively based perspective (LCB teachers), teachers with a more cognitively based perspective (CB teachers) make extensive use of word problems, even in addition and subtraction. More cognitively based teachers also have greater knowledge of their students' problem solving strategies than did the LCB teachers. Students with CB teachers scored higher on word problem-solving achievement than did students with LCB teachers, but students from both types of classes did equally well on addition/subtraction number facts and calculations (Peterson, et al, 1989).

These findings suggest the possibility that students in CB teachers' classes are able to master computational skills and number fact knowledge concurrently with their development of word problem-solving skills. Moreover, these students mastered number facts as well as the students in the LCB teachers' classes, where greater emphasis was placed on mastering computational skills than on problem solving.

The findings are relevant because girls' strong performance in computation is based (1) on the activities and teacher-student interactions of early grades; (2) on success in rote memorization and rule following; (3) in being "the good student" -- these are all interrelated tools. Then, in later grades, problems-solving activities increase and the girls do not adjust well: (1) they are not used to risk taking; (2) they have fewer experiences with the teacher letting them guess and strategize; (3) it has been less acceptable for them to be "wrong." My argument for this project is that now, with New Standards calling for more and earlier problem solving, the girls will be better versed at it. An argument against this logic might ask why girls would pick up the problem solving skills and autonomous learner behavior now (in early problem solving classrooms.) The answer is that the culture of the classroom, and the social and historical experience of the students is at play. That is, the girls will not be "indoctrinated" so to speak, in the "good girl" activities of the computation lessons.

These LCB/CB findings help us to see that all students (both male and female) in more CB classrooms do well on calculations. CB teachers reported placing less emphasis on students' learning of calculations than on their word problem solving and understanding. CB teachers encourage more strategizing and risk taking and focus on the problem solving rather than on the number facts and computation skills. Boys' confidence would remain high, as they are encouraged to take risks and explore meaning. Furthermore, in this context, girls' success would no longer rely on rote memorization and rule following as evidence of their ability to follow teacher-framed rules. Instead, girls could be "good students" by taking risks and collaborating on meaning as the teacher encourages this behavior.

In addition to teachers' behaviors, school activity and the institution's context can affect learning behavior in a variety of ways with effects on perceptions of competence and values related to different domains of achievement. By providing gender-role influences through textbooks, games, and adult role-models, school contributes to occupational plans by socializing gender stereotypes and reinforcing behavior consistent with these stereotypes (Stipek, 1992). The teacher's reinforcing behavior of stereotypes, in turn, affects student confidence in learning by differentiating behavior among peers.

In the context of a classroom activity that requires the whole group to negotiate both meaning and control of the talk, understanding teacher-student and peer interactions is crucial. Goodnow (1993) remarked on the challenge that faces every analyst of such interactions and emphasized the futility of dichotomizing theories of individual constructivism and socially guided constructionism. Instead, she encourages perspectives which can use the two theories to strengthen each other, such as an approach that emphasizes development as the acquisition of shared meanings (Goodnow, 1993). By understanding the complexities of the discourse of whole group discussions we can describe this acquisition of shared meanings among participants. Educational and developmental researchers have taken such a perspective on classroom talk recently, but the study of language in the classroom did not start this way.

Studying Language In The Classroom. By the early 1960's, evidence accumulated about causes of student failure that had to do with language. In the historical, social, political context of that era it is not surprising that investigations focused on social-class differences in language use, and on minority groups whose first language was not English. The resulting "deficit model" of language competence was used to bolster enrichment programs like *Head Start* and *Follow Through.* The intent was to rectify a deficit in social class that appeared to affect language use and learning by providing earlier opportunities for exposure to the "proper" forms of educational language (Adelman, 1981).

Around the same time in the United States the study of language enrichment in schools was popular but included little scientific research focus on the social context of discourse and its affects on language performance. Even in linguistics studies, researchers focused on universals and sought generalities, which characterize a language, not discourse. In the seventies there developed a stronger research interest toward language in particular settings in order to understand the variability of language to a fuller extent (Shuy, 1978). Much of this work started with British researchers' investigations into social and class inequities in education.

In Great Britain there is a long history of debate about the differences between working class and middle class educational performance and connections to what Bernstein (1971) termed "restricted" and "elaborated" codes to indicate the structures underlying the "manifestations of language." Continuing the critique of the deficit model of language was significant work that took into account the social contexts of talk in school classrooms. Combined with research such as the ethnographic monitoring of classrooms by Hymes (1980) and the social class research of Cazden (1972), the book Functions of Language in the Classroom (Cazden, John, & Hymes, 1972) and Labov's The logic of nonstandard English (1970) marked the establishment of a socio-cultural perspective on language use in the schools (cited in Adelman, 1981).

In reviewing the first decades of linguistic analyses of classroom talk, Edwards and Westgate (1987) provide a powerful argument for extending the analysis of classroom talk from a linguistic one to a communicative one to more fully understand the nature of classroom activity. Such research has included many investigations of student peer interactions, mainly in small groups and dyad activities especially in literacy and more recently in science and math .[7] Much of this work has focused mainly on the talk in small groups and dyads rather than on the talk in whole group discussions. One reason that the discourse of whole-group discussions has only recently been investigated is the practical difficulty that has existed in accurately recording naturally occurring discussions of large groups (Edwards & Westgate, 1987). Current historical shifts in the nature of

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7 For examples of classroom discourse and small group activity in general see Barnes & Todd, 1977; Bauersfeld, 1992; Cazden, 1986; Cooney & Ladd, 1992; Michaels & Collins, 1984. For specific studies in science see Halliday & Martin, 1993; Morse & Handley, 1985; Reddy, 1994; in math see Cobb & Bauersfeld, 1995; DeCorte & Vershaffel, 1987; Lampert, et al, 1996; O'Connor & Michaels, 1993; Stigler, 1997.

whole class discussions (i.e., those advocated by the New Standards for mathematics) call for new understandings of the activity of student talk. Whole group classroom talk is the focus of the present project because of the opportunity it affords students to socially display anxiety, confidence, and control of their learning regarding the learning of mathematics.

Different Structures of Classroom Talk. Traditional classroom talk has most often been described as it exists in the three-move interaction of teacher initiation- student response - teacher evaluation recitation style [IRE]. This "exceptionally prevalent" feature of classroom discourse (Edwards & Westgate, 1987) constituted over half of total interactions in Mehan's (1979) early discourse studies and detailed analyses of nine separate classrooms. The IRE exchange also crosses boundaries of age and nationality as investigated by Burton (1986) for its use in British elementary schools; by Mehan (1979, 1984) and by Heath (1983) in American elementary schools; and by Edwards and Furlong (1978) in secondary schools. This recitation structure exists in both simple and complex classroom discourse. In complex discourse situations it is sometimes embedded within a much larger discussion, separated by other categories of talk yet always returning to the question at hand - the initiation, and typically ending with a teacher evaluation (Westgate & Edwards, 1987).

The pervasiveness of the IRE exchange is expected in traditional educational practices wherein the teacher is the leader of the classroom and the center of the learning activity. In providing the framework for discussions, the teacher asks according to her knowledge and evaluates according to her values (Mehan, 1979; Cazden, 1986; Walkerdine, 1988.) In turn, the students answer according to what sense they have made of the teacher's knowledge and values (Walkerdine, 1988). Within such a teacher-centered discourse structure, reinforcements for gendered behavior is guided by the teacher toward the students. This is a key conceptual argument for the implication that classroom discourse profoundly affects students' learning experiences. During "official discourse" the teacher controls classroom interactions. Using the basic recitation script, teachers can initiate, regulate, and terminate all interaction and can manage the allocation of student turns (Cole, 1998).

Official, recitation scripts are not the only discourse in the classroom[8]. Students also learn how to negotiate an "unofficial" system of communication among peers. Current research has documented "unofficial" (not IRE) discourse that represents students' attempts to work out a connection between the "official" and their own discourse. Gutierrez, Rymes & Larson (1995) identified points in a discussion when students appeared to be having separate conversations, but found that the discussion was not a "counter script" but earnest attempts by students to make sense of the teacher-controlled classroom content (Cole, 1998).

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[8] One example is Bauersfeld's (1992) variant to the IRE exchange is an "elicitation pattern of interaction" (EPI). The teacher's questions still develop from their own perspectives on the math lesson, but the questions ask more about student thinking. Through a sequence of questions and answers the teacher guides the students toward the correct answer, or the point of the lesson. Yet, this talk is still teacher directed.

Although the recitation paradigm dominates classrooms in the United States and other industrialized countries there have been many attempts to implement alternative participation structures in classrooms. Physical arrangements of classrooms have been changed to encourage different social and activity relationships among peers, and between students and teachers. Efforts have also come and gone to insure that content is "of interest to students" (Cole, 1998). The history of attempts to replace teacher-centered instruction with child and activity centered instruction began with what Dewey (1938) referred to as progressive education. [9]

In the current mathematics pedagogical shifts, as the teacher's role becomes less that of an absolute authority, one can expect discursive exchanges other than the official scripts. Such classrooms fall into categories like "child centered", "progressive", or "constructivist." Across school systems and among a variety of educators these terms are used differently to describe a range of reform approaches. For the sake of the present discussion, the terms are used to categorize a pedagogical approach that is not teacher-centered, "traditional", or "official." Activities in classrooms such as these attempt to be framed around students' knowledge and students' interpretations of activity, thus necessitating new structures of classroom interaction. These new structures should represent not only more student-centered talk, but more student centered control of content. Students should be able to initiate, regulate, and terminate interactions, thereby

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[9] A review of the history of attempts at student-centered instruction is available in Cuban (1993).

acquiring more control in the activities of their sense making. Their sense making interactions now become more a part of the "official discourse", rather than the "unofficial" attempts at understanding lesson content through the sidebar conversations documented by Gutierrez and colleagues (1995).

The developing model of communication between students and teachers describes a more complex interaction in which a conversation develops from student-generated ideas and activities rather than teacher-owned "facts about math". In this way, teacher's questions are no longer cues for students to follow (to a teacher-valued end) but are elaborations on the student's own knowledge and meaning making (Cobb & Bauersfeld, 1995).

For example, during the whole group discussions of end of the lesson "wrap-up" students have an opportunity to share the strategies, adjustments, and learning moments that occurred since the introduction of the problem during their small group work. Students use wrap-up to explain procedures from the beginning of an activity (e.g., a reminder of a shared piece of information) and proceed to define moments of confusion (disequilibrium), arguments (discord among small group members), resolutions (accommodation), and the formation of big "ideas" (development of math concepts). In talking about their activities and thinking, the students negotiate meaning -- about number, operations, concepts -- in a social context of cognitive development. The relevance of this context and of these new forms of interaction is discussed below in light of the current historical changes taking place in mathematics instruction and classrooms.

Math Pedagogy in the Current Historical Moment

In 1989 the National Conference of Teachers of Mathematics (NCTM) called for sweeping changes in mathematics, recommending that problem solving and student centered learning be the focus of school mathematics. These math specific mandates reflect the current generation of education reforms begun since the federal report, *A Nation at Risk* (1983) and the subsequent attempts at systemic reform. In support of this focus, educators have suggested pedagogical changes that would alter the teacher's role from transmitter of ready-made concepts and procedures to creator of conditions for students to construct "their own" mathematical knowledge. Such a shift in pedagogy means a shift from mathematics instruction as a decontextualized and abstract science toward one that is more contextualized, real-life meaningful, child constructed, and child centered (Zalkower, 1997.) Such pedagogical shifts are manifest in characteristics of institutional culture and classroom practice such as classroom talk and control of information.

Teachers implement change in their instructional styles with varying degrees of success. Combined with teachers' systems of values and beliefs about mathematics, changes in the curriculum occur at different rates for different teachers and are manifest in qualitatively different ways. Where curriculum approaches are changing toward the principles of constructivism and child centered education the teacher may need to surrender certain characteristics of his or her role as expert in an attempt to shift the responsibility for the construction of knowledge to the students. One such characteristic is that of the teacher as leader of discussions.

Changes in Classroom Talk. Since the 1960's education researchers have used observation schedules with predetermined systems of categories to understand how classroom interaction is organized (Edwards & Westgate, 1987.) Classroom talk, particularly in group discussions, traditionally has been led by the teacher and functions within the frameworks of the teacher's goals, knowledge, and values (as discussed above.) Such talk is manifest in the traditional structure of IRE verbal exchanges (Edwards & Westgate, 1987; Mehan, 1976).

The new standards (NCTM, 1996, 1998) that call for a mathematics curriculum that is process rather than product oriented (that is, with an emphasis on problem-solving strategies rather than on reports of answers) should result in new forms of classroom talk. Such classroom talk would deviate not only from the traditional recitation (IRE) exchange structure but also from the somewhat more progressive elicitation (EPI) exchange structure described by Bauersfeld (1992). Both types of classroom talk are still essentially focused on and directed by the teacher's goals, knowledge and values.

On the other hand, the classroom talk that has developed out of the more child centered and constructivist programs functions within the framework of the students' knowledge, negotiations, and developing ideas. This type of talk focuses on social constructions of knowledge, on dyadic peer interactions, small peer groups, and whole class discussions. Such classroom talk is expected then to deviate from the traditional exchanges, which are still essentially focused on the teacher, toward more student-centered discourse.

While some research efforts have been made to classify teacher questions and their functions, surprisingly little attention has been paid to the parallel area of instructional discourse -- that of explanations (Westgate & Edwards, 1987). A better understanding of the complexities of classroom talk that goes beyond teacher questions, for instance, explanations -- both from teachers and from students, is necessary in light of the new standards that demand more student discussion. On an instructional spectrum with traditional teacher roles at one end and progressive teacher roles at the other more student discussion means, on the one hand, increased teacher explanations to spur class discussion and, on the other, increased student explanations as peer groups construct meaning socially. In either case, "more student talk" can occur, but in the latter case the student talk should reflect more student thinking. Thus, in the former case, while teachers could get their students to talk more, the students are merely talking more about the teacher's ideas about math.

In the more constructivist and child centered classrooms different communicative demands are made on students than in traditional classrooms. In place of teacher-directed (IRE) verbal exchanges, students have to explain more of their thinking processes, interpret others' thinking and expressions, and engage in meta-cognitive discussions. These new demands require students to explore their thinking and explain their activity to both the teacher and their peers. Phillips

(1985) finds children's perceptions of their peers as communicative partners more conducive to exploratory talk than their perceptions of "unchallengeable" teachers. Teachers, too, find themselves in a new communicative context. Instead of overt questions and demands, they narrate and create problem-solving contexts, guiding but also reacting to student activity and student discourse.

A simple example of how teachers' discursive roles can change revealed itself during my own visits to math classrooms over the last five years. I noticed that teachers in "constructivist" classrooms do not evaluate students' responses, whether they are correct or not (Switzer, personal communication, April, 1997). That is, teachers have eliminated the "E" in the IRE exchange. This simple elimination reflects a dramatic change in the structure of typical IRE classroom talk, even if nothing else about the talk is changed. Without the teacher evaluation, classroom talk is more likely to (1) proceed in a recurring two part exchange, as described by Bauersfeld's (1992) EPI structure, or (2) allow for student evaluations in their comments about peers' meanings. In either case, control over the validity of math statements - e.g., descriptions of strategies, assumptions of principles, and values about mathematics information - comes less from the teacher and more from the students than in traditional IRE structured classrooms.

Changes in classroom talk are evident in the education literature describing successful and efficient changes in classroom practice. Characterizations of such practice include discussions that are based more on the behaviors of students than on the behaviors of teachers. Bridges (1990), for example, presents several minimal conditions for genuine class discussion: (1) students talk to each other (and not just in dialogue with the teacher); (2) students listen to each other; (3) students are responsive in word and thought to what others say; and (4) the talk is purposeful in relation to the development of understanding the topic under discussion. Such characterizations are not possible in traditional IRE exchanges and are contrary to the common assumption that teachers' behaviors and techniques are the primary determinants of instructional effectiveness. This contradiction compromises established traditional roles in the classroom.

Changes In Power Roles. Changes in classroom discourse reflect changes in classroom roles. In a traditional classroom the teacher is the mathematics expert and the talk about mathematics is framed and constrained by her goals and knowledge. In a constructivist classroom mathematics knowledge is meant to be built by the students (NCTM, 1989, 1991, 1995). The control of information in such a classroom is dependent on student-generated ideas and questions while they share strategies and build meaning through classroom talk.

One example of student control of information is found during small group activities. For example, some teachers have adopted a "resource rule" for the class whereby a student or students with a question must refer to another student for help. If this resource is not sufficient, they turn to a student work group. Students with questions can only turn to the teacher if the question remains unanswered after all other efforts have been exhausted (Switzer, 1996). In this way the responsibility for information and learning is clearly valued as a student owned and shared commodity. Shared understanding of this information is then publicly negotiated during the whole-group discussion, as students play a greater role in this discourse activity.

Student control of information does not necessarily mean more equitable learning. As a commodity, this kind of classroom talk is embedded within issues of power and control that develop in the new activities as some students come to dominate certain leadership roles and classroom conversations about math. Hence, what ideally is meant to empower all students may still only benefit a few, for example, those students who speak aggressively (Lott, 1994), those who are ahead of the group in mathematical understanding, or those of the dominant class (Bourdieu, 1973). Whether this type of classroom talk can affect boys and girls differently is the focus of the present investigation.

In the classrooms that are struggling to change mathematics instruction according to the NCTM New Standards, boys and girls should have increased opportunities to actively learn. There are two ways these new classroom dynamics can affect girls differently than traditional classroom dynamics. First, girls may be at an advantage in the new forms of classroom talk because the themes of talk that are encouraged are characteristically more feminine - sharing ideas, accepting and valuing differences, and helping others to understand (Tannen, 1990; Walkerdine, 1986; Gilligan, 1982). These are quite different from the more masculine, competitive style of traditional IRE classroom talk in which there is usually one right answer and few opportunities to give it, fostering more competitive styles for students to show what they know -- a forum in which boys have excelled (Fennema & Peterson, 1985.)

The second way that girls may be at an advantage is that, in the current context of changing paradigms of teaching mathematics, problem solving begins earlier and can co-exist with or supplant rote learning and computations. So, not only girls but also all students may be at an advantage in so far as they have an opportunity to participate, to take risks and, ultimately, to develop learning behavior that strengthens their confidence in their abilities to learn math.

The possibility of such gender equity is somewhat mitigated by a few persistent factors of classroom culture. For instance, boys who are more aggressive get more attention from the teacher (Cohen & Blanc, 1996; Lott, 1994). Teachers' inadvertent gender bias could continue to affect the distribution of gender in classroom talk if teachers retain management of speaker turns in wrap-up discussions. On the other hand, students also have the opportunity to choose who will speak and could show same-sex preferences in their choices. For example, students sometimes elect who will represent their small group to the class, and then the presenter, in turn, can choose questions "from the floor". If aggressive behavior receives more attention than passive behavior, then students who interrupt (typically boys) may take control of the talk (Bojesen, 2000). In this case, greater control of the talk and participation in the talk is in the hands of the students. Reddy (1994), in her close look at fourth grade science wrap-up discussions, used post-hoc gender analyses and found small but persistent gender differences when students were presenting and allowed to choose which peers could ask questions.

Concerns such as these have not yet been investigated in group talk as they relate specifically to math confidence. In light of the recent emphasis on increased problem-solving and student talk about math (NCTM, 1995), I will describe, in the following section, the different ways that math can be talked about and how this relates to gender differences in problem solving and calculations.

Changes in Math Activity. When Fennema and Lamon (1991) separated math performance into specific domains they found two significant differences between gender. The first was that girls perform better at basic arithmetic and calculations. The second was that boys perform better in problem-solving. The significance of these differences in domain specific performance is enormous when one considers that once basic arithmetic is mastered, much of school mathematics activity develops from problem-solving contexts. So, while girls excel in early grades when calculations are traditionally taught, their performance declines in the later grades, and afterwards in middle and high school, when problem solving is the focus.

Fennema and Lamon's findings were based on reviews of student performance. They did not investigate causes of such domain specific differences. Studies since then consider a possible link between performance and aspects of the classroom culture or, specifically, instructional style.[10] In other words, if early instructional styles promoted a different set of "acceptable behavior", such as one more focused on problem solving", girls could endeavor to be as "good learners" as when the rules of behavior to rote learning and calculations. A perspective such as this reflects a theory that gender differences exist, not as a matter of student ability, but as a matter of perceptions of appropriate behavior and the nature of the attitudes and activities involved in that behavior.

Calculations traditionally entail rote memorization and unambiguous basic arithmetic operations toward absolute correct answers. That girls excel at calculations is consistent with the findings that describe girls' tendencies to follow rules rather than to search for understanding (Fennema &Peterson, 1985; Walkerdine, 1983). Typical calculation lessons easily fall into recitation (IRE) structures of teacher-student interactions in which the student's input is usually framed by the teacher's own values, beliefs, and knowledge (Cazden,1986; Walden & Walkerdine, 1985; Edwards & Westgate, 1987). Girls are confident in their math ability when the content (calculations, simple rules) and the discourse structure (IRE, teacher centered) coincide. Their decline in confidence comes when the content (problem solving, exploration & strategy testing) and the discourse structure (IRE, teacher centered) do not reflect one another. Problem

10 The recent TIMMS cross cultural study of (3rd, 6th, 8th grade) math classrooms in the U.S., Germany, and Japan is the largest such endeavor and has inspired many follow up investigations of math classroom culture (Timms, 1999.)

solving and strategy testing are better talked about as processes, whereas calculations and rote learning fall naturally into talk about product and solutions.

Three example follow to illustrate this argument. These exchanges were recorded during my visits to math classrooms. Numbers have been changed so that they are the same in all three examples in order to illustrate the differences in talk structure about what is essentially the same math problem.

(1) In it's simplest form the IRE structure is typified by the following exchange:

Teacher:	What is twenty times fifty six?	Initiation
Student:	A thousand a hundred and twenty.	Response
Teacher:	Good.	Evaluation

Here, the teacher looks for the answer - the product, not the process - or math understanding. Clearly, she knows the answer already, and the quickest response could be seen as the most clever. It hardly seems to matter whether the student had a chart or multiplication table from which to literally "find" the answer, or the student figured it out on a calculator.

(2) Even when the teacher's question is shifted to how to find the answer, where an operation can be algorithmically taught, and the focus is on the process of the algorithmic activity, the exchange is similar in structure. For example (the coding schemes can be found in the appendix) :

Teacher:	How do we find out twenty times fifty-six?	Elicitation
Student:	You write down the fifty--six and then put the twenty under it.	Response
Teacher:	That's right.	Uptake

Teacher:	Then what?	Elicitation
Student:	You multiply zero times everything is zero. Then two times six is twelve, carry the one, two times five is ten, plus the one is eleven.	Response
Teacher:	Good,	Uptake
Teacher:	and what is the answer?	Elicitation
Student:	one hundred and twelve.	Response
Teacher:	No, you're forgetting something.	Uptake
Student2:	I know. The zero.	S. Information
Teacher:	Right. The zero.	Uptake
Teacher:	What's the real answer?	Elicitation
Student:	Oh, a thousand and one hundred twelve.	Response
Teacher:	One hundred what?	Uptake
Student:	[pause] I don't know. [pause] Oh, one hundred twenty.	Response
Teacher:	Alright, let's move on.	Uptake

In this example the final points are made based on the student having forgotten the zero in the one's column. Negotiations here are about rules of procedure in an algorithm more than they are about the student's number sense. In fact, the exchange ends when the teacher closes the interaction with an evaluation remark about what is, actually, still only a partial answer. The correct answer is one thousand one hundred and twenty, but when the student forgets the place value of the zero he is thrown off by the question "One hundred what?" He never states the complete correct answer. When using a vertical multiplication algorithm, such as this, the final answer is the one place to assess number sense. The processes leading to the final answer are a series of computations.

It is easy to see how, in this exchange, the teacher is in control of the interaction. The teacher's questions guide the student toward information that the she already has, namely how this algorithm works.

Alternatively, within the new standards of math teaching, math instruction involves more open-ended activity and more indicators of students' mathematical thinking. The combination of the ambiguity of presentation, i.e. in a word problem, and the necessity for students to make sense of what is being asked of them means that they can not hide behind their success in simply following the rules. The open-endedness of problem-solving, even at a simple level of instruction, provides opportunities to expand the typical (IRE) recitation exchanges toward (EPI) elicitation exchanges that includes more student input, and eventually toward more conversational classroom talk centered around student's mathematical thinking.

(3) In the following example the arithmetic problem is essentially the same (56 times 20) but this teacher framed it within a context of seating arrangements in the school auditorium. The students here talk about their number sense and their thinking about arrays that lead to properties of multiplication. This excerpt occurred during the wrap-up.

Teacher:	Nick, explain the strategy your group used with this problem.	Elicit
Student:	Well we know there were twenty rows so we made a map of the auditorium with twenty rows and then 56 chairs go in each row. And we thought if there was a path, like a path, down in the middle	Resp

	where you walk then it could be ten rows and ten rows. Then I knew that ten 56's is five hundred sixty, so I just doubled that.	
Teacher:	Hmm, I'm a little confused. How did that path get there?	Uptake
Student 1:	We put it there.	Resp
Student 2:	We put it there because we all were like, "If it was times 10"	S.Info.
Student 1:	Right 'cause we knew fifty six times ten.	S.Uptake
Teacher:	How did you know?	Elicit
Both students:	Friendly numbers	Resp
Teacher:	Alright, we all love the tens table. Now how about the doubling.	Info
	Can someone else tell us what they think that was all about?	Elicit
Student 3:	They had to double because they made the twenty into 2 tens.	Resp
(new group)	They only had half the chairs on one side.	S.Uptake
Student 4: (new group)	That's not really like an auditorium. The path should be down the middle. Then there's 28 and 28, but still you have 20 rows.	S. Info
Student 1:	Well I thought of that but we liked ten. So the chairs go back.	S. Info

In this exchange student talk not only exceeds teacher talk; it reflects activity, thought, negotiation, meaning, and understanding. As this discussion continued, the students contextualized their mathematical thinking not just within the framework of the original problem but within the demonstrated thinking of their peers. In this simple multiplication activity alone, there are thirty minutes of talk about the different strategies for solving the equation [56 X 20]. This contrasts sharply with the approximate ten seconds of talk in the previous two examples about the same math equation.

It is clear there are more opportunities for student questions and student answers than in the traditionally structured talk. The talk is more about process than it is about product, and the evaluation component - the teacher's value - is not even represented. Yet, this is not to say that length of discussion is the key difference. For a comparison of thirty minutes of product-based, teacher-centered talk and process based, student-centered talk see the transcripts for Teachers #2 and #6 in appendix C.

The discussion sample above culminates in conclusions about patterns of strategies that reveal mathematical concepts. A lesson such as this can lead to students' own construction of an algorithm for double-digit multiplication. In the last example, for instance, after a well-guided discussion of different geometric strategies for finding area [56 X 20] the class might extend the different strategies to the multiplication problem to "the big idea", or principle, of the law of commutativity [(56x20) = (20x56)], or associativity [(56x10)x2 = 56x(10x2)]; or a combination of the two [(56x2)x10].

The importance of the problem-solving issue to girls' experience cannot be overemphasized. It is the catalyst of current debates between new reforms or a "back to basics" stance in curriculum and assessment reforms. It is the one area in which many researchers have reached agreement that gender differences exist (Fennema & Leder, 1990; Taal, 1994). Certainly if boys can gain an upper hand in confidence in this domain, girls can too. One way that this could happen is in schools where problem-solving is instituted in early grades as the context for most mathematics activity. As a result of the New Standards for Mathematics (NCTM, 1995) many schools are in the process of instituting earlier problem solving in the curriculum. The participants for this study are from schools like these, experiencing change in the math curriculum to varying degrees.

An Example Of Pedagogical Change: The Mathematics Training Program

The teachers whose classrooms were used for this project are enrolled in an in-service teacher training program for a constructivist mathematics curriculum. Teachers attended an intensive two week summer workshop followed by their regular teaching year during which they met once a week with a mentor and once a week with their cohort of trainees for continued math and pedagogy workshops. The summer workshop was conducted as a retraining for the teacher's own mathematics understanding and the follow-up year focused on implementing the new curriculum in their classrooms. Another focus was on changing the source of math activity from text books and teacher's knowledge -- as if math were a preset series of activities -- to the real world and students' activity in it -- so that math is an ongoing activity upon the world. In fact, to "mathematize" is a verb form introduced to participants to help them turn every day real world events and objects into activities for understanding math.

The workshops focused on breaking the habit of teaching mathematics as the reduction of a problem to an algorithmic computation. A striking point is made early in the summer session about how algorithms are tools and cultural inventions to solve math problems, but they are not math themselves (although many of us are trained to think otherwise.) The workshop leaders ask the teachers to explain how they were taught to work out a multi-digit multiplication problem. The diverse group of teachers produced a variety of algorithmic approaches to the same problem. When these were combined with international algorithm examples provided by the staff it was soon apparent that there is no "one, correct" way to multiply compound numbers. The teachers began to question why they would teach their students any one particular "way."

Thus began their mathematics re-education. The teacher's task is to present a "context problem" to the students so that they experiment with different strategies to solve it. After the introduction of the problem students separate into established small groups to investigate strategies. Small group activity is followed by a wrap-up discussion, or "math congress." These activities are described below.

Introduction Of The Word Problem. A mathematics "context problem" is a problem-solving story more complex than the traditional text book word problem. It features a story embedded in a context, which should be relevant or meaningful to the student population (in this population, for example, urban rather than rural.) The complexity of the story provides constraints to the students' activity toward solving the problem. Sometimes the problem is embedded within other content areas in the classroom, for example social studies or science. A teacher with thirty students in her class might introduce a simple division problem (sixty divided by eight) like this:

> Tomorrow night is parents night here at school. We have to have room for all of your parents to sit in the classroom. I never know until the last minute if every parent will attend so we have to make room for everyone, just in case they all do come. So, let's assume two parents are coming for everyone. The custodian will bring up some more tables if we ask him today. He told me that no more than eight adults can fit at each table. How many tables do we need altogether.

The teacher can elaborate on this version according to the math needs of her group. In this particular version, she has provided some constraints and left out some information for particular reasons. For example, by not providing the number of parents she doesn't force the students into an immediate division situation (total parents divided by eight). She points out that eight can fit at a table, eliminating a "counting by tens" strategy. She uses a number that will leave a remainder, necessitating an extra table, which might confuse students who are skip counting to reach sixty. She doesn't point out how many students sit at each table, which allows her to see which students think of this information and try a strategy based on doubling. Had this been her intent, though, she may have ended the introduction by noting, "Four of you sit at each of our tables right now. How can that information help us figure out what we need for the parents?" thereby, encouraging the use of doubling, and ratio.

A problem such as this could be a bridge between addition and multiplication. Since students are never "at the same level" such a problem allows for a variety of strategies for the groups to discuss later.

The possibilities of variations and constraints in a context problem are many and can be easily extended, according to the level of the students' mathematical development. This "parents' night" example could have started as a transition lesson between multiplication and division, and it could be easily extended toward a geometric lesson by figuring out the most efficient arrangement of desks within their classroom.

Small Group Work. After the introduction to the problem the class separates into small groups to work on the problem, using resources of their choosing (usually manipulatives or charts, pens, paper - depending on level of understanding and math concept of focus.) This activity can be redirected by the teacher through changes to the original problem. Interruptions to the small group work can occur, for example, because of daily scheduling or teacher announcements of changes to the problem.

An average class is divided into five groups of five students each. The composition of groups is usually arranged by the teacher and can be adjusted throughout the year for a variety of social, behavioral, and pedagogical reasons. Occasionally, students elect their own groups. The teacher's arrangements of small groups afford ZPD and/or team collaboration depending on the student's needs.

<u>Strategies and Models</u>. A strategy is, in effect, the activity used to solve a problem [rounding to the nearest tens for many operations; doubling.] A term occasionally confused with strategy is model. Models are usually conceptual mathematics representations [a pie to illustrate fractions; a passengers on a bus story to illustrate repeated addition/subtraction.] They are tools, shortcuts, helpers. The choice of a particular model is discussed as a strategy. Sharing and understanding the variety of strategies that develop from the small-group work takes place during the wrap-up discussion.

<u>Wrap-up Discussion.</u> After a period of small group activity the class reconvenes in a group (usually at "the rug area") to present different strategies in a "wrap-up". The purpose of this group discussion is to use the variety of students' strategies to build on prior concepts and to draw conclusions about mathematics principles based on patterns of strategies. The students are at various levels of mathematics competence, possessing different levels of conceptual understanding. Socializing the group's work reinforces the theory that knowledge is based in activity and mediated through language, through zones of proximal development, negotiations of shared meaning, and accommodation of ideas and concepts.

Wrap-ups appear to be the most difficult of the math activities for the teachers. Some of the teachers remarked that the training program is more thorough in assisting teachers to develop new math problems and guide their students during small-group work than it is in teaching the logistics of managing a large group discussion in a student centered manner. This pedagogical dilemma is consistent with recent observations by some researchers that "no one ever talks to teachers about talking" (Saxe, 1997; Stigler, 1997; Kawanaka, 1997). Yet, as changing instructional paradigms and the New Standards call for more discussion among students the teacher's understanding of classroom talk is paramount.

During wrap-up the teacher's role is newly compromised by the shift in control of information from her to her students. During the introduction of the problem the class is centered on the teacher because she has the information necessary for the next step. During small group work the teacher maintains much of her or his traditional role by moving from group to group, assessing students' work. During wrap-up, she knows some of what will emerge from the students' thinking, from her observations of the small group work. But, as she cannot be at all the small groups all the time, she cannot be certain of what will emerge from the students' thinking while the group discussion unfolds in wrap-up. The teacher can guide the discussion so that the students can explain their activities, share their ideas and make connections to larger mathematical concepts. In so doing the teacher relinquishes control of the conversation so that students question and answer each other rather than the teacher, and the teacher plays a role more akin to participant observer than gatekeeper of information. This is in contrast to the role that the traditional teacher plays in a recitation lesson whereby everyone knows that she or he has the information, the right answer, and if students play the game right, they will get to it too.

Relevance

The paradigm shift espoused by the New Standards (NCTM, 1989, 1991) calls for a variety of pedagogical changes. The new standards demand that teachers become facilitators of students. As this new facilitator role is not explicitly described by either the NCTM or specific staff development programs, one would expect the changes in teachers roles to come in a variety of stages. The roles are possible in a range of teacher behaviors from the traditional recitation one - leading children to the teacher's solution, to a more elicitation model, to nothing but monitoring and asking questions.

In the present project, I focused on how classroom talk organized as a "community collaboration to make sense of mathematical ideas" (NCTM, 1995) allows more gender equity in the development of math ideas and confidence in math ability. Such talk is not only student-centered but functions without the traditional structure of the teacher's math knowledge framework and is subject to the dynamics of the group's variety of goals, knowledge, and values rather than those of the teacher (Bauersfeld, 1992). In the teacher training program from which the present participants were pooled, the "math congress" event (herein referred to as "wrap-up") is a whole group discussion convened after a math investigation to allow learners to present, defend, and discuss their strategies, puzzlements, and ideas in a mathematical community of peers (Fosnot, 1989). This form of class-talk is just one of the changes in classroom practice that teachers currently face.

Such changes in the classroom occur slowly, if at all. Some teachers, who can respond appropriately to questions about their methods, do not necessarily have the skills to put changes into practice. An understanding of what such discussions look like, how they are controlled, and how they affect students is paramount both to convincing teachers that such change is effectual and to assisting in girls' exposure to positive mathematics activity. The present investigation explored the variations in math wrap-ups so as to distinguish between teacher and student centered discussions and their relationships to students' attitudes about their mathematics learning.

Research Question

The general question posed by this investigation was: Are boys' and girls' attitudes and beliefs about their math learning affected by the kinds of wrap-up discussions in their classrooms?

The different types of math discussions were classified as traditional, recitation style, and teacher directed, or reflective of current reforms, and student centered. The students' attitudes and beliefs about their math learning were measured in students' confidence in learning math and in students' attributes of their success and failure in mathematics.

The specific research questions concerned (a) gender differences between within the two types of discussion groups ; (b) gender differences between the two types of groups; and (c) differences in girls between the groups and in boys between the groups.

Hypotheses

I hypothesized that student-centered discussions provide the sociocultural context that affords certain learning behavior. These behaviors are supportive of problem solving confidence for both boys and girls. Furthermore, this confidence relates to students' attributions of success and failure in math to themselves rather than to external forces. Conversely, I hypothesized that the students in teacher-centered classrooms would exhibit the same gender differences that have been highlighted in the literature, presumably in traditional classrooms, namely that girls lack confidence in their math learning and attribute their success in math to forces other than their ability (such as effort, luck, outside help) and their failures to lack of ability, whereas boys attribute their success to ability and their failures to lack of effort or to external forces.

The general hypothesis is that classroom discussion style impacts students' math confidence and attributions of performance. Specifically, in the classrooms with higher rates of student-centered talk, boys and girls will score high and similarly on the math ability confidence measure, and in the teacher-centered classrooms there will be a gender difference, with the girls scoring lower, in students' confidence in their math's abilities.

The hypotheses for student confidence, and attribution of success and failure are:

(a) Within groups: there will be a gender difference in the teacher-centered classrooms (simple main effect of gender, given treatment);

(b) Within groups: there will be no gender difference in the student-centered classrooms;

(c) Between groups: there will be a difference between the groups' gender differences.

Method

The goal of this project was to understand girls' attitudes and beliefs about learning mathematics in the context of whole class discussions. In groups that were differentiated by the teacher-centeredness versus student-centeredness of their class-talk interactions, gender differences among the students were compared in measures of their math confidence and in students' attributions of success and failure in math.

Research Design

This study employed a quasi-experimental design. Participants were students and teachers in an already existing math training program. Because of the non-random assignment of participants, every effort was made to take into account relevant variables. The teachers were participants in a constructivist math training program but they implemented instructional changes in their classrooms differently from each other. One such difference was used to discriminate between student-centered classrooms or teacher-centered classrooms depending on the structure of verbal exchanges during wrap-up discussions. In order to increase comparison validity in this nonrandom assignment I also gathered school, teacher, and student descriptive data. Two student outcome measures -- confidence in mathematics learning, and attribution of success and failure in mathematics were administered to both groups.

Participants

Students. Participants were one hundred ninety six girls and boys from eight heterogeneous classes of fourth and combined fourth/fifth grade classes in New York City public schools. Based on criteria described in the "Descriptive Data" section below, four teachers' classes were assigned to the student-centered group (49 girls and 48 boys) and four teachers' classes were used as the teacher-centered group (49 girls and 50 boys). The sample size supports comparison of means of the student measures by gender within groups (boys and girls in teacher-centered classes versus boys and girls in student-centered classes) with a predicted medium effect size and alpha .05 (Cohen, 1992). Because the hypothesis predicted no difference between gender in the student-centered group, it was especially important to increase power with a large sample size.

The students ranged in age from 10.0 to 11.25 years. This age group was used because it is the point when declines in attitudes toward mathematics have been found to begin (Hyde, et al, 1990; Bell, et al, 1983). This age period is also described as the end of an important period of the development of skills related to interpersonal problem solving and perspective taking (White & Blacham, 1985;

Marsh, 1982; Shantz, 1975.) Such skills are relevant to the present study as they relate to the interactive, social, and problem solving nature of the math activity.

Students were heterogeneously assigned to these general education classes by their schools; the classes were neither advanced nor behind in terms of mathematics. Their classrooms shared the following characteristics:

- approximately 25 students per classroom
- one teacher per classroom
- a student teacher, para professional, or math staff developer visited once a week
- math was taught at least four days a week, at approximately the same time, for thirty five to forty five minutes.

Selection and availability of teachers. The teachers in these classrooms participated in the constructivist math training program for four years. This participation took place within a context of heightened awareness of the necessity for and expectation of change in math classroom practice. These expectations are described by the recent New York City "Performance Standards", and the NCTM "New Standards" that emphasize contextual learning, critical thinking, problem solving skills, and more student participation in mathematics lessons.

Using these teachers from the same training project provided more controlled conditions than would have been possible in a random selection of classrooms from a random selection of schools. The classroom instructional activity (problem-solving) and the lesson content (fractions, parts of whole, multiplication) were similar for both groups during the data collection. In all of the classrooms the teachers introduced the problem solving activity and the students proceeded with small group work.

The teachers knew me as the evaluator for the teacher training program (described in the section on the "Current Historical Moment", Page 69). I came to know them through my weekly visits to their classrooms during the prior four years, and from weekly workshops at the teacher training program site over the prior four years. The students and teachers were accustomed to visitors in the classroom. I visited all classrooms bi-weekly throughout the semester prior to videotaping so that the curriculum schedule was familiar and so that I would know the classes' routines. This facilitated the scheduling of the data collection period.

School Demographics. The eight classrooms were in five different public schools in New York City. Three schools provided matched pairs in the two class-talk categories; schools A, B, and C had both a teacher-centered and a student-centered classroom. The fourth teacher-centered class was from School D and the fourth student-centered class was from School E. Standardized math scores, the schools' demographic data, and school mission statements were taken from reports published by the NYC Board of Education (NYCENET, 1998). See Appendix A for a table of school demographic data.

Three of the schools scored higher than the city average (92%) of students who scored at or above their grade level in a state-wide mathematics test. The two others schools (C and D) scored just below the city average, both at 87%. To reflect the cohort of students that participated in this study the third grade math scores were used from 1997 since the participating students were in fourth grade in 1998.

The ethnic make up of the student bodies varied in four ways. School A's student population of Asian, Hispanic, Black , and White students was similar to the city average of majority Hispanic and Black students, followed by White, then Asian students. The student populations of schools C and E were majority Black and Hispanic, school B had majority Black students, and School D had majority Hispanic students.

The English language proficiency of the schools' students (LEP) was similar to the city average except in School D where more than half of the students have limited proficiency. The poverty index was high for all of the schools except schools A and E, both of which fell below the city average. New immigrant status of the schools' students was comparable to or below the city average, except in schools A and D which had slightly more new immigrants than the city average. These data are listed in the appendix.

Child-Centeredness of The Schools. The schools were categorized as high, medium, or low in their constructivist and child-centered approach to mathematics education, see table 1. Both types of classroom discourse are found in the three school types. Thus, I discount school approach as relevant to the teacher or student centeredness of the classroom discourse. These ratings were based on interviews with principals, the mission statements of the schools, and interviews with the math coordinators in each district (Kelly & Glick, 2001). A school with a high score emphasizes process over product in students' math work and uses the development of students' concepts as a guide for curriculum. A school with a low score emphasizes product over process in students' work, especially in terms of student performance in state and city tests. A low scoring school relies on external forces (the "structure" of mathematics, pacing calendars, text books) rather than the development of students concepts to guide the curriculum.

Table 1

School child-centeredness.

School	Teacher ID's*	Rank
A	1, 6	High
B	2, 7	Low
C	3, 8	Low
D	5	Medium
E	4	High

*TC classrooms are teachers numbered 1, 2, 3, 4
SC classrooms are teachers numbered 5, 6, 7, 8

Context for analyses

In this project, comparisons are made in the context of classroom wrap-up discussions to describe the kind of environment in which the students are learning. This social environment is one of interactive activity, beliefs, attitudes and culture. One reason to investigate student confidence in this context is the social nature of wrap-up discourse compared with the one-on-one nature of the recitation discourse. Furthermore, wrap-up provides an opportunity to see how information is controlled according to students' development and shared for the whole classroom rather than for small groups, or individuals. Discursive events during small group work are based on the teacher assessing students' attention to the task, attending to behavior problems, and interacting with the individuals or small groups on one topic. However, wrap-up discussions provide a context for sharing of ideas and negotiating meaning. Students' beliefs about their abilities develop in relation to their activities in this social context.

The current historical moment in mathematics education finds pedagogical issues focused on increased student participation in both the construction of math concepts and the sharing of ideas. Furthermore, although the use of small group activities is widespread in math classrooms (as well as in other subjects), experiences in wrap-up are still diverse. Classrooms are in transition from traditional methods to the new ones; teachers are at varying stages of belief about the utility of these changes. There is less research of whole group discussions, like those found in wrap-up, than there is of small-group interactions. Small-groups are also used in a variety of subjects other than mathematics, so teachers of various levels of expertise are able to facilitate small group activity. On the other hand, the whole group wrap-up event, as a student-centered activity appears more difficult for teachers. For instance, in the math training program described above teachers reported that wrap-up is frequently neglected altogether. Reasons cited are lack of time in the classroom schedule; teachers are reluctant to give up control to the students; and teachers are unsure of their role in wrap-up conversations.

Teachers' beliefs and backgrounds are also considered a contextual component. Whether or not the class engages in recitation or more open styles of discourse is a matter of the teachers' beliefs, ability, and style. The teachers' own education, in mathematics and in teaching, and their work experience contribute to the dynamics of the classroom.

Instruments

Several measurement strategies were used. Three instruments helped to define the comparison groups. Two instruments were used for student outcomes. They measure students' confidence in ability to learn math, and their attributions of math failure and success. Teacher and a student questionnaires provided additional descriptive information.

System For Observation Of Mathematics Education (SOME). The SOME inventory was used for preliminary data collection during observations of wrap-up. Although the original inventory was developed to categorize math activity, I used it to categorize math talk -- what teachers said about math activity, and how teachers asked students to talk about their math activity as either mechanical or meaningful events. This scale was developed at the Max Plank institute and used to distinguish classroom activities that are procedure oriented, rote and "mechanical" tasks based on simple facts from structure oriented, "meaningful" mathematical activities, based on concepts (Renkl & Helmke, 1992). This construct has been associated with theoretical assumptions that performance oriented, mechanical tasks promote the automatization of basic arithmetic skills, whereas structure-oriented, meaningful tasks foster math problem-solving competencies.

This instrument was designed for low-inference observation of teacher-student interactions. It is a closed-event sampling system that uses a set of predefined categories (closed) and is coded by the occurrence of events (event sampling) rather than time intervals. Teacher utterances during wrap-ups are tallied in six categories: three describe mechanical learning - learning by rote; and three describe meaningful learning - conceptual knowledge.

Talk Sequence Observational Inventory. By adding modifications to the SOME instrument (which tallies events) I developed an additional inventory to record sequence of discursive events during my observations of wrap-up. The resulting Sequence Inventory used the six teacher and student utterance categories of the TIMMS videotape classroom study (Stigler, 1999). The instrument allows the observer to record and identify turn function (e.g., elicitation), source (teacher or student), and structure (location in interaction) throughout the class discussion. The instrument thus provides both a flow of conversation categories from which to analyze structure of talk and an inventory of types and frequencies of teacher and student talk.

Teacher Beliefs About Student Learning Process in Math Scale (SLPMS) Teachers completed the SLPMS, developed by Peterson, Fennema, Carpenter, & Loef (1989.) The range of possible scores on each of the four subscales is 12 to 60. A low score on this scale indicates the belief that students actively construct mathematical knowledge and supports a constructivist viewpoint of mathematical learning (von Glaserfeld, 1987). The four subscales were combined to create a 48 item survey with half the items reversed for scoring through out all of the subscale constructs. This version was used by Moore (1993) in a comparison of novice and expert teachers' beliefs about mathematics instruction. The four subscales are arranged with their respective twelve items in appendix B.

(I) Scale I is concerned with how children learn mathematics. This scale's continuum goes from the belief that children construct their own knowledge (score 12) to the belief that children receive knowledge (score 60).

(II) The continuum for this scale goes from the belief that skills should be taught in relationship to understanding and problem solving to the belief that skills should be taught in isolation from understanding and problem solving.

(III) The continuum for this scale goes from the belief that children's natural development of mathematical ideas should provide the basis for sequencing topics for instruction to the belief that formal mathematics should provide the basis for sequencing topics for instruction.

(IV) This scale is concerned with how mathematics should be taught. The continuum for this scale goes from the belief that instruction should facilitate children's construction of knowledge to the belief that teachers should present knowledge.

Students' Confidence in Learning Mathematics Scale. This scale was taken from the Fennema - Sherman Mathematics Attitudes Scales which are nine domain specific, Likert-type scales measuring attitudes related to the learning of mathematics by females and males (Fennema & Sherman, 1976). Each scale consists of 6 positively stated and six negatively stated items with five response alternatives: strongly agree, agree, undecided, disagree and strongly disagree. Each response is given a score from 1-5. A person's total score on each of the scales is the cumulative total and the higher the score, the more positive the person's attitude. The scales can be used as a package to assess a variety of attitudes toward the learning of mathematics, or, the scales can be used individually. For this project, the Confidence in Learning Mathematics scale was used.

The Confidence scale is intended to measure confidence in one's ability to learn and to perform well on mathematical tasks. The dimension ranges from distinct lack of confidence to definite confidence. The scale is not intended to measure anxiety and/or mental confusion, interest, enjoyment or zest in problem-solving.

Students' Mathematics Attribution Scale. The Mathematics Attribution scale (MAS) was designed to measure students' attributions of causality of success and failure experiences in mathematics (Fennema, Wolleat, & Pedro, 1979). The scale was developed for high school students so simple modifications in the phrasing of item statements were made, as instructed by the scale's creators, to reflect the level of math in these 4/5 grade classrooms. Three fourth grade students from different schools assisted in the modifications of terms about math and school practice so that they were appropriate for their grade level.

The MAS is composed of eight clusters of items. Four clusters have success event stems and four have failure event stems. Each stem is followed by four causes (attribution statements) which correspond to four attribution categories ---- ability, effort, task, environment. Subjects read each event and respond to each attribution statement on a 5-point Likert type scale.

Teacher Ratings of Students. There is evidence that teachers reinforce different behaviors for boys and girls (Eccles & Blemenfeld, 1985, Stipek, 1992); and expect different behavior from boys and girls (Daneck & Joseph, 1983). Teacher ratings have also been used to detect relationships between teacher attitudes toward students and students' talk. For example, without defining for the teachers what they meant by "effectiveness," Griffin and Shuy (as cited in Mehan, 1979) asked primary school teachers to rank their students on the effectiveness of their language use. They compared these ratings to categories of student talk (such as conciseness and ability to get point across) and discussed the reflexive relationship between teacher perceptions and student participation.

Teachers were asked to rate their students' problem solving ability on a scale from one to five. Each student received a score based on the teacher's rating. Student scores fall between 1.0 and 5.0. A low score indicates weak overall math ability and a high score indicates strong overall ability.

Student Background. Attached to the final page of the student instrument packet was a questionnaire with fill-in items about age, birth order, and parental involvement with homework. The peer nomination questions were at the bottom of this page.

Student Peer Nominations. A measure of sociometric status was used to understand the social context within which students talked about their math ideas and to provide insight into the students' perceptions of boys and girls as good at math. I separated social desirability from task desirability by first giving them an opportunity to name two classmates with whom they would like to "hang out" after school. All nominations were to be scored as a proportion of the total number of children in the class so that each child received a score ranging between 0.0 and 1.0. Instead, because some students named classmates that did not participate, I analyzed the same sex and cross -sex patterns of nominations.

Procedures

All data were collected during the spring of 1998. Observations and video recordings of the wrap up discussions were scheduled when the classroom math units were comparable. The student surveys were administered during May and June, 1998 in the student classrooms.

Observational Inventories. Two inventories of each of the two observation instruments (SOME and Sequence) were taken during four separate visits to each of the eight classrooms. When possible, the video recording was made during one of these visits and when necessary a fifth visit was made to audio/video record the wrap-up discussion. The visits ranged from four days to four weeks apart for any one classroom depending on the scheduling of similar lesson units for each classroom. Longer waits between visits occurred in the teacher centered group (classrooms # 1 through #4) than in the student centered group. The procedures for the two observational inventories were the same, except that time intervals, using a stop watch, were used for the Sequence inventory and not for the SOME inventory. During observation inventory visits the examiner sat in the back of the room during a wrap up discussion and recorded the talk using the paper inventory instruments.

The teachers knew that I was looking at "math congresses" or "wrap-ups" and told me when they expected to have one. Each whole class discussion used for this project was considered a congress or wrap-up by the classroom teacher.

Group Discussion. The group discussion was videotaped by one hand-held camera that was mobile and able to record individual speakers. The video recording provided identification of speaker by gender when it was unclear from the audiotape. A stable, table top audio-recorder with a more sensitive microphone than that on the video recorder was used to supplement the transcribing process. In the classrooms in which teachers decided against video recording, these audiotapes were used as primary data sources.

The group discussions lasted from twenty to forty minutes; the video recordings continued until the discussion was complete. In all four classrooms of the student-centered group (teachers numbered 5 through 8) the entire class gathered at a "rug" area for these discussions and it was simple to capture individuals as they spoke. In all but one of the teacher-centered groups (Ingrid, #3) students stayed at their desks so the video recorder was set up at one side of the room at an angle to record the whole group and to move for focus on students who moved to the blackboard.

Four teachers' wrap-up discussions were video/audio taped (two student-centered, and two teacher-centered). Of the remaining four, three had reservations about videotaping in the classroom and so were audio taped (two student-centered and one teacher centered). The eighth teacher took a sudden leave of absence from the school so it was not possible to record a group discussion in that classroom.

Student Survey Instruments. The student survey which included the Confidence scale, the attribution scale (MAS), and the background questionnaire with peer nomination were administered to students during class time on a non audio/video recording day. Students were seated at their desks with the surveys in front of them. I read the instructions and went through the steps of the sample questions out loud for the three sections separately. I emphasized that there are no right or wrong answers for any of the questions and that parents and teachers would not know the students' responses. Students then completed the Confidence scale on their own, waited for the whole class to finish, and I then read instructions for the MAS. Students completed this section then proceeded to the background section. Throughout the administration of this survey I reminded the students that they need only raise a hand if they had questions. This survey administration took from twenty to thirty minutes. I collected each survey when a student indicated he or she was done by raising a hand. I checked that all the items were complete and in this way suffered no missing student data.

Teacher Survey Instruments. A package that included the teachers' student rating scale, background questionnaire, and SLPMS scale was delivered to teachers with a prepaid return envelope. One teacher (Lou, #5) did not complete the ratings of his students.

Reliability of coding. A second coder was trained to use the observational inventories with two pre-existing videos not used for this project, but recorded with teachers in the same math training program. We independently coded four sets of five minute segments of both videos, first with the SOME inventory and then with the Sequence inventory. Correlations between her codes and my own for these videos were .93 for the SOME items, and .90 for the Sequence items. This second coder collected twenty percent of the wrap-up SOME and Sequence data.

<u>Coding And Transcription Procedures</u> The wrap-up recordings were transcribed a soon as possible after taping, using the audio recordings as primary source and video recordings when necessary to verify gender of speaker and non-speakers in the group. The data were transcribed in sequence of speaker turns using the CHAT transcription system so that frequency counts and future analyses could be made with the companion CLAN program (MacWhinney, 1995). Speaker turns were defined, with the guidelines from the TIMMS (1999) project analyses of math discourse, by changes of topic or focus, and did not count repetitions.

Teacher and student utterance categories from the TIMMS video research project:

Elicitation	E	A teacher utterance intended to elicit an immediate communicative response from student(s), including both verbal and non-verbal responses.
Information	I	A teacher utterance intended to provide information to the student(s). Does not require communicative or physical response from students.
Direction	D	A teacher utterance intended to cause students to perform some physical or mental activity. When the utterance is intended for future activities, it is coded as Information even if the linguistic form of the utterance is a directive.

Uptake	U	A teacher utterance made in response to student verbal or physical responses. It may be evaluative comments such as "Correct," "Good," or "No," repetition of a student response, or reformulation of student response. Uptake is intended for the respondent, and when it is clear that the utterance is intended for the entire class, it is coded as Information instead of Uptake.
Teacher Resp.	TR	A teacher utterance made in response to a student elicitation.
Response	R	A student utterance made in response to an elicitation or direction.
Student Elicitation	SE	A student utterance intended to elicit an immediate communicative response from the teacher or from other students.
Student Information	SI	A student utterance to provide information, but not intended to elicit an immediate response from teacher or from other students.
Student Direction	SD	A student utterance intended to cause the teacher or other students to perform immediately some physical/mental activity.

Student Uptake	SU	A student utterance intended to acknowledge or evaluate another student's response.
Provide Answer	PA	A teacher utterance intended to provide the answer to that teacher's own elicitation. (Or SPA, student answers own question.)
Other	O	An utterance that does not fit into any of the above categories or that is not intelligible.

(Stigler, et al, 1999, p. 105)

Rapport Building And Pilot Tests

I observed the teachers at their jobs in their own classrooms and as students in the training program workshops between August, 1995 and June, 1999. I participated in the intensive summer workshops with four cohorts of teacher trainees (1995 - 1998) and continued observing them through their inservice training during each of the following academic years. Pre-training videotapes of a sample of these teachers provided the initial motivation to investigate the language in the classroom as I saw both distinct differences and striking similarities among the teachers.

What the teachers and students talk about makes sense differently depending on whether it is new material or a review, whether it involves the whole class or a few students, and whether it relates to visible work or not

(Lemke, 1993.) Having observed these teachers for four years (and these particular students for the prior semester) I was able to see how what they were saying could make sense as a comparison variable. All the teachers addressed the same math activities as small group events, but not all of them carried through to the wrap-up discussion in comparable ways.

Teachers in the project were from grades Pre-K through sixth. Because the city school system moved the sixth grade from elementary to middle school buildings during the second year of this project, the fifth grades became the eldest of the student population. Many of the schools combined fourth and fifth grades in one teacher's classroom. These classes were approached to participate in my project and eight of the fourth and fourth/fifth grade teachers were available.

Having observed them for four years I was confident that the teachers fell into two categories of classroom talk. I thought of one category as very traditional and teacher directed. The other category was difficult to define, but certainly different from the teacher-centered. Clearly the students were talking more frequently, but I was not sure how to qualify that talk. At first I used a crude observational inventory to establish the frequency of speaker and basic talk categories. I began to see a connection between recitation talk and the talk about basic calculations and rote learning on one hand and more conversational talk about problem solving and conceptual ideas on the other. I then identified the SOME inventory. This inventory, developed by the Max Planck Institute, categorizes mathematical activity as either mechanical or meaningful. In piloting this instrument in other classrooms during the academic year preceding my data collection I found that the resulting data were well arranged to categorize and quantify the classroom talk by activity but not to qualify the nature of the interactions or the sequence of turns of talk.

Using my experiences with the earlier SOME inventory and the preliminary reports from the TIMMS study that had just then been published, I developed a second instrument. This is the Sequence inventory used to track speaker turn and turn category. I decided to keep the SOME inventory data as well because they resulted in distinct categories of "mechanical" and "meaningful" teacher initiations between the two groups (as defined by Renkl & Helmke, 1992).

Descriptive Data for Group Distinctions

After the classroom observation inventories were completed, and recordings of the wrap-up discussions were transcribed, the data were analyzed to establish ratio of recitation exchanges to total wrap up talk. The eight classrooms were assigned to two groups based on a median split for recitation frequency. Additional data from the wrap-up discussions, teacher beliefs, and background information further describe the groups. Group means of these descriptive variables are shown in table 2. Individual classroom means can be found in appendix A, table 17.

Categorizing the Classrooms

Contingencies of talk were used to describe the differences in classroom discussions based on high and low proportions of recitation (IRE) exchanges. Teachers who exhibit more control of the discussions, as evidenced in a high proportion of characteristic recitation (IRE) exchanges, are in the "teacher-centered" (TC) group. Teachers who allow the students more control in the discussions, as evidenced by a low proportion of IRE exchanges, are in the "student-centered" (SC) group.

Data for the structures were gathered from three wrap-up observations in each classroom -- twice using a real time inventory during whole group discussions, and once using the video recordings of the third lesson. Data from the sequence inventories show the order of speaker turns and utterance categories so that contingencies and categories of talk could be tallied. Two quantifiable measures were taken to categorize discussions as either teacher or student centered. First, a priori criteria for categorizing a discussion as teacher-centered (TC) or student-centered (SC) relied on the frequency of recitation (IRE) exchanges. Second, the remaining (non-IRE) talk was categorized as either teacher or student dominant.

Thus, in order to categorize a TC discussion, the frequency of three-part (IRE) recitation sequences had to be greater than the frequency of any other teacher-student exchange in the talk. In addition, the remaining talk had to be dominated by teacher utterances. The criteria for categorizing a SC classroom were that the frequency of IRE sequences was smaller than that of any other exchange, and the remaining talk was dominated by student utterances. The three wrap-up data sets for each of the eight classrooms were first analyzed separately and then rates of talk were combined for mean proportions of talk.

Table 2

Group means of frequency of wrap-up criteria differences.

Classroom	IRE interactions [1]	IR interactions [2]	Mechanical Initiations [3]	Meaningful Initiations [4]	Teacher talk [5]
TC	.47	.08	.76	.24	.70
SC	.17	.09	.22	.78	.37

[1] Mean ratio of three-part recitation interaction to total talk during wrap up (SEQUENCE inventory)
[2] Mean ratio of two-part (teacher-student) interaction to total talk during wrap up.
[3] Mean frequency of mechanical initiations by the teacher (SOME inventory)
[4] Mean frequency of meaningful initiations by the teacher (SOME inventory)
[5] Mean ratio of teacher utterances to total talk
** Missing data

IRE exchanges. In classrooms One, Two, and Three IRE exchanges represented over 54% of total utterances in each of the classrooms. In contrast, IRE exchanges were infrequent in classrooms Five, Six, Seven, and Eight representing from 5% to 20% of total utterances.

The discussions in classroom Four were made up of only 10% IRE exchanges, and so on first analysis were categorized with the SC group. However, after later analysis it was clear that the remaining talk (90% of total talk) was dominated by the teacher giving information and providing answers to his own questions, leaving no opportunity for any other student participation. Therefore, after secondary analyses, classroom four was included in the TC group, bringing the group mean to 47% IRE exchanges.

Teacher talk. In the TC classrooms teacher utterances made up an average of 70% of the entire wrap up. The talk that remained after accounting for IRE exchanges was also dominated by teachers. It was comprised of teachers' directives, teachers' information, and teachers providing answers to their own questions.

In the SC classrooms teacher utterances made up an average of 48.51 % (range .28 to .60) of the wrap up discussions. Talk was shared with or dominated by the students and categories of utterance were varied for both speaker types. The group means for the distribution of teacher talk categories are shown in Table 3. These group means appear comparable, but the differences among individual classrooms can be found in appendix A, table 18.

Table 3

Group means of teacher talk categories* during wrap-up

Group	Elicitation	Information	Directive	Uptake	Response	Provide Answer	Other
TC	.46	.18	.06	.26	---	.03	---
SC	.40	.19	.09	.27	.02	.01	.02

* Mean ratio of category distribution in teacher-talk

Student talk. In the TC classrooms, after accounting for IRE exchanges, almost none of the remaining talk came from students. The "R" (response of the IRE exchanges) constituted over 94% of all student talk.

On the other hand, the discussions in the SC classrooms were dominated by student information and student to student uptake. In addition, and in contrast to the TC classrooms, student utterances included elicitations, directives, and providing own answers to their questions. Group means for the distribution of student talk is shown in table 4, below. Differences among the individual classrooms are shown in appendix A, table 19.

A related output of this array of criteria was that the overall talk in the TC discussions was distributed almost uniformly across three of the fourteen code categories: Teacher elicitation, Student response, Teacher uptake. On the other hand overall talk in the SC discussions was represented by all fourteen possible categories, for both teachers and students.

Table 4

Group means of student talk* during wrap-up.

Group	Elicit	Inform	Directive	Uptake	Response	Provide Answer	Other
TC	.01	.07	---	.01	.90	---	---
SC	.07	.31	.02	.17	.40	---	.04

* Mean ratio of category distribution in student-talk.

Mechanical and meaningful talk.

Data from the SOME inventory reflect differences in how teachers initiated talk about math activity. Teachers in the TC classrooms asked questions exclusively about the rote learning and the processes of computation whereas teachers in the SC classrooms asked questions about math principles, concepts, and students' metacognitive thinking. Table 5 summarizes the wrap-up discourse differences between groups.

Table 5

Summary of Wrap-Up differences between groups

Teacher Centered Talk	Student Centered Talk
Classrooms 1-4	Classrooms 5-8
More than 54% IRE exchanges	Fewer than 20% IRE exchanges
High ratio of teacher talk	High ratio of student talk
Teacher utterances are primarily elicitations and Uptakes	Teacher utterances are distributed among all categories
Student utterances are primarily responses	Students utterances are elicitations, directives, information, responses, uptakes

Teachers' role in the context of analysis

Whether teacher or student centered, the wrap-up discussions are a process made possible by the teacher. In order to more fully understand the contribution of the teacher to this context of analysis, and to the differences between the groups, I collected a variety of information about the classroom teachers' experience. education, and beliefs.

Teachers' Backgrounds. The teachers' ages ranged from 31 to 50 years. All teachers' ages were in the low to mid thirties, except two (in the TC group)who were older. All but one of the teachers completed or were in the process of completing a masters degree; all have at least six years of experience teaching the same grade level, but two of the TC teachers have over ten years; all but one (in the TC group) have been at the same school for at least the last 5 years. There were two male and two female teachers in both groups. The teachers' level of participation in the math training program was evaluated for attendance and quality of leadership-level by the instructors of the math training program, and found to be comparable though teachers in the student-centered group scored slightly higher.

Self-Reported Math Teaching Style. The teachers were asked to describe their method of teaching mathematics as if they were explaining it to a colleague interested in joining the training program. The question was so framed to give the teachers the opportunity to utilize the discourse of the training project, yet to speak in practical terms about realistic classroom applications. As a result of their participation in the math training program the teachers were frequent participants in the dissemination of the project's mission -- either at the request of their school principals, or of the training project staff. Thus these teachers were accustomed to describing the mathematics approach to people both with and without familiarity to the constructivist math project. I wanted to compare how the teachers used terms related to constructivism and child centeredness, and terms that concern the development of math concepts in students.

All teachers described their approach to teaching mathematics with similar phrases like "problem solving activity", "investigations", and other terminology that reflected terms that describe the mechanics and activity of the training program. Only the student-centered teachers used terms that referred to students' thinking, the development of math concepts in students, and other terminology that resonated with the meanings behind the approach of the training program.

Student Learning Process In Mathematics Scale (SLPMS). The results indicated that the range of scores on the four subsections was different between the two groups, as show in table 6. below. The SC teachers scored lower on all subsections indicating the teachers believe that children construct their own knowledge (rather than receive it), that skills should be taught in relation to problem solving and student understanding (rather than in isolation), and that the role of the teacher is to guide the development of ideas rather than deliver "established" information.

Table 6

Group means of Teachers' scores on subtests of the (SLPMS)*

	Classroom Group	N	Mean	Std. Deviation
How children learn	TC	4	28.00	11.89
(construct or receive knowledge)	SC	4	17.75	3.30
Relate or isolate skills	TC	4	32.25	8.77
(from problem solving)	SC	4	22.00	6.83
Development of ideas				
(from child or	TC	4	28.50	5.20
"formal mathematics")	SC	4	21.00	6.06
Role of teacher	TC	4	23.00	12.25
(facilitate construction	SC	4	16.00	2.94
or present knowledge)				

*A low score indicates the belief that students actively construct knowledge and supports a constructivist viewpoint of mathematical learning.

Summary

The primary criterion necessary for a classroom to fall into one of the two groups was that the majority of exchanges between students and teachers were identified as IRE interactions. By their very nature, these exchanges result in higher proportions of teacher than student talk. Any non-IRE talk in the TC group was comprised of teacher, not student, talk. Classrooms with discussions that met this criterion became the teacher-centered [TC] group. The talk in classes for the other group could not be characterized as IRE. This classroom talk was dominated by students and is called the student-centered [SC] group. Data from the SOME inventory supported differences between these groups, suggesting a relationship between teacher-centered talk and mechanical talk on the one hand and between student-centered talk and meaningful talk on the other. The teachers' scores on the SLPMS indicate that the SC teachers have stronger beliefs in a cognitive, student-centered approach to teaching math. However, all teachers self-reported a math teaching style based on constructivism and student centeredness. The results of the group data are summarized in Table 7.

Table 7

Summary of group differences

Classrooms 1-4 TC classrooms	**Classroom 5-8 SC classrooms**
IRE structures dominate wrap-up	Non-IRE structures dominate wrap-up
More Teacher talk	More Student talk
Teachers initiate talk about *mechanical* activity	Teachers initiate talk about *meaningful* activity
6 to 17 years teaching experience	6 years teaching experience
Self-reported constructivist teaching style	Self-reported constructivist teaching style
Low Cognitive Based Beliefs about how math is learned and how it should be taught	High Cognitive Based Beliefs about how math is learned and how it should be taught

Results

The student Confidence and Attribution outcomes were compared using a contrast measure for gender differences within both classroom groups and a comparison of these gender differences between the two classroom groups. Figure 1 below illustrates these three comparisons with the mean scores of student confidence.

Student Confidence in Learning Mathematics

My first research question asked whether boys' and girls' confidence in their math learning abilities differs depending on the type of classroom talk in their classrooms. The confidence in learning mathematics scale resulted in a cumulative score (possible range was from 12 to 60), with the higher score indicating greater confidence in the student's ability to learn mathematics. The

Table mean confidence scores for the students in the two classroom groups are shown in Table 8 and in Figure 1.

Table 8

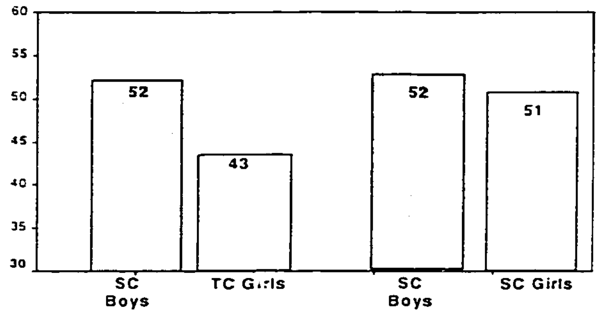
Mean scores of student confidence in ability to learn mathematics.

Classroom Group	Mean score	N	Std. Deviation
TC male	52.16	50	7.80
TC female	43.35	49	7.15
SC male	52.48	48	6.20
SC female	50.63	49	8.28

I hypothesized that gender differences would occur in the teacher centered (TC) classrooms, but not in the student centered (SC) classrooms. I used a one way ANOVA with three contrast statements to determine (1) gender differences in the TC group, (2) gender differences in the SC group, and (3) to contrast these within-group differences between the two groups. Figure 1 illustrates these three comparisons.

Figure 1

Mean Score of Students' Confidence in Learning Mathematics.



1. The hypothesis that within the TC group there would be gender differences in students' confidence in math ability was supported. A significant gender difference was detected in the TC group in student's confidence in their ability to learn math, t (192) = 5.92, $p < .001$.

2. The hypothesis that within the SC group there would be no gender difference in the students' confidence in math ability was supported. No significant differences were detected between the boys' and girls' confidence measures in the SC group, t (192) = 1.228, $p = .221$.

3. The hypothesis that gender differences in student confidence within the TC group and within the SC group would be different between the two groups was supported. The gender difference in students' confidence in the TC group was significantly greater than the (lack of) gender difference in the SC group, t (192) = 3.29, $p = .001$.

A comparison of means found the TC girls scored significantly lower than all three other student groups, at the .05 level*, as shown in Table 9.

Table 9

Comparison of TC girls' confidence mean to remaining groups.

(I)Classroom Group	(J)Classroom Group	MeanDifference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower	Upper
TC male	TC female*	8.81	1.49	.000	4.99	12.64
	SC male	-0.32	1.50	.997	- 4.16	3.52
	SC female	1.53	1.49	.734	- 2.30	5.35
TC female	TC male*	-8.81	1.49	.000	-12.64	- 4.99
	SC male*	-9.13	1.50	.000	-13.00	- 5.27
	SC female*	-7.29	1.50	.000	-11.13	- 3.44
SC male	TC male	.32	1.50	.997	-3.52	4.16
	TC female*	9.13	1.50	.000	5.27	13.00
	SC female	1.85	1.50	.609	- 2.02	5.71
SC female	TC male	-1.53	1.49	.734	- 5.35	2.30
	TC female*	7.29	1.50	.000	3.44	11.13
	SC male	-1.85	1.50	.609	- 5.71	2.02

Student Attributes of Success and Failure in Mathematics

Results of the eight combinations of the mathematics attribution scale (MAS) were compared with the same analyses used for the students' confidence scores: two within group and one between groups. The eight attribution combinations were:

success - ability	failure - ability
success - effort	failure - effort
success - task	failure - task
success - environment	failure - environment.

The mean scores for students' attributions are shown in Table 10 for attributions of success, and in table 11 for attributions of failure.

Table 10

Mean scores of students' attribution to success

CLASSTALK Group		N		success-ability	Success-effort	success-task	success-environment
TC	**male**	50	Mean	12.32	12.56	11.00	12.56
			Std. Deviation	2.94	1.92	2.59	1.98
TC	**female**	49	Mean	10.14	12.04	11.27	12.31
			Std. Deviation	3.16	2.27	2.22	2.18
SC	**male**	48	Mean	11.58	10.85	10.73	10.67
			Std. Deviation	2.25	2.29	1.95	1.56
SC	**female**	49	Mean	10.41	10.92	10.55	10.92
			Std. Deviation	3.00	2.62	2.54	2.45
	Total	196	Mean	11.12	11.60	10.89	11.62

Table 11

Mean scores of student's attributions to failure

CLASSTALK Group		N		failure-ability	failure-effort	failure-task	failure-environment
TC	**male**	50	Mean	7.12	6.64	8.24	6.08
			Std. Deviation	2.81	2.86	3.16	2.64
TC	**female**	49	Mean	8.76	8.31	9.1	7.67
			Std. Deviation	3.05	2.25	3.09	2.31
SC	**male**	48	Mean	6.75	6.98	8.25	7.52
			Std. Deviation	2.65	2.59	2.53	2.47
SC	**female**	49	Mean	7.94	8.10	9.65	8.55
			Std. Deviation	3.29	3.56	3.36	3.03
	Total	196	Mean	7.64	7.51	8.81	7.45
				3.04	2.92	3.09	2.76

The hypotheses that concerned the students' attributes of their success and failure in math were organized in the same three ways as were those for the students' confidence scores above. I used a one way ANOVA with three contrast statements to determine: (1) gender differences within the TC group, (2) gender differences within the SC group, and (3) to contrast these within-group differences between the two groups.

1. Within the TC group there will be gender differences in students' attributes of success and failure. This hypothesis was partially supported.

Success. A significant difference was detected between the TC boys' and girls' attributions of success to ability $t = 3.785$ (192), $p < .001$. However, no significant gender differences were detected in the remaining three success constructs (effort, task, environment) for the TC group.

Failure. Significant gender differences were found in three of the four possible failure constructs: the attribution of failure to ability $t = -2.748$ (192), $p = .007$; the attribution of failure to effort $t = -2.901$ (192), $p = .004$; and the attribution of failure to environment, $t = -3.016$ (192) $p = .003$. The TC girls attributed failure to these three constructs more than the boys did. No significant gender difference was detected in the TC students' attribution of failure to effort.

2. Within the SC group there will be no gender difference in the students' attributions of success and failure. This hypothesis was partially supported.

Success. Analyses of variance detected no significant gender differences for SC student's attributions of success in any of the four constructs.

Failure. Analyses of variance detected a significant gender difference in one of the four failure constructs. Contrary to my prediction, in the SC group, the boys and girls attributed their failure to task differently, $t = -2.262$ (192), $p = .025$. Here the girls attibuted their failures to task more than the boys did. For each of the remaining three failure constructs (ability, effort, environment) there were no gender differences in the SC group.

3. Gender differences in student's attributions within the TC group and within the SC group will be different between the two groups. This hypothesis was not supported.

Success. Analyses of variance for each of the four success constructs detected no significant differences between the gender distributions in the TC and SC groups.

Failure. Analyses of variance for each of the four failure constructs detected no significant differences between the gender distributions in the TC and SC groups.

Frequency of Participation by Gender

Proportions of participation by gender in both types of classroom discussions were compared. There were no gender differences in the frequency of utterance between groups.

Peer Nominations

Data from the peer nominations for "good math group members" were problematic because some students nominated peers who did not participate in the study. The original intent of this measure was to give each participating student a score for how frequently he or she was nominated by the rest of the class as someone "desirable as a math group member". Instead, I used the results of the peer nominations to describe the percentage of students who nominated peers of the opposite sex, whether or not that nominee participated in the study.

Boys and girls in the TC classes tended to nominate their own gender, but a few girls nominated boys as well, whereas only one TC boy nominated a girl. Students in the SC classes were more equitable in their peer nominations. While the majority of all students nominated their own gender, both boys and girls in this group nominated peers of the opposite sex in all but one of the three SC classrooms. The percentages of students' nominations for peers of their own or the opposite sex is shown in Table 12.

Table 12

Percentage of students that nominated peers

TC Group	Boys nominate girls	Girls nominate boys
1 (24)*	0 (12)	0 (12)
2 (24)	7.69 (13)	27.27 (11)
3 (31)	0 (15)	6.25 (16)
4 (20)	0 (10)	10.01 (10)

*Total numbers of students in each group are in parentheses

SC Group	Boys nominate girls	Girls nominate boys
5 (19)	44.44 (9)	50.0 (10)
6 (28)	42.84 (14)	21.42 (14)
7 (30)	13.33 (15)	6.66 (15)
8 (20)	0 (10)	0 (10)

Teacher rating of students

Teachers rated their students' problem solving ability on a scale from 1 to 5, ranging very weak to very strong overall ability. I hypothesized that teachers in the TC classrooms would rate boys higher than girls, and that teachers in the SC classrooms would rate boys and girls the same. This hypothesis was supported. A one way ANOVA, with three contrast statements was used to detect differences within and between the groups in the same way that the Confidence and Attribute scores were analyzed.

Table 13

Teacher rates student ability

Group		Mean	N	Std. Deviation
TC	male	4.08	38	.88
TC	female	3.13	39	1.00
SC	male	3.53	38	.69
SC	female	3.38	40	.74

1. A significant difference was detected in the teachers' ratings of students in the TC group, $t = 4.979$ (151), $p = .000$.

2. No significant difference was detected in the SC group, $t = .797$ (151), $p = .426$.

3. A significant difference between these group differences was detected, $t = 2.969$ (151), $p = .003$.

Discussion

The main objective of this project was to investigate the hypothesis that girls' confidence about their math abilities is related to the discursive classroom contexts in which they are engaged as learners. This hypothesis was based on theories that gender differences in student behavior are socially constructed rather than biologically based and that classroom cultures are contexts in which these social constructions develop. It was expected that in classrooms dominated by a teacher-centered recitation style of discourse (TC classrooms) the girls would have lower confidence than the boys would. Conversely, in classrooms dominated by student-centered open style of discourse (SC classrooms), boys and girls would have equally high confidence in their math abilities.

The findings suggest that contexts of teacher-student recitation interactions about the mechanics of math provide a learning environment conducive to gender differences in students' beliefs about their abilities to learn math. Conversely, contexts of student-centered discussions about the meanings of math provide a learning environment conducive to both boys' and girls' strong confidence in their abilities to learn math. The results indicate a relationship between girls' confidence and the classroom context in which they learn mathematics. The girls in the TC classrooms scored lower than boys in both classrooms and lower than both boys and girls in the SC classrooms on the measure of their confidence in ability to learn math.

This discussion focuses first on the contextual factors surrounding girls' low confidence in the TC classroom context and then on the factors surrounding gender equity in the SC classroom context. I explore how girls' confidence in these contexts relate to the theories of learning behavior (Fennema & Peterson, 1985), good student behavior (Walden & Walkerdine, 1985), and cognitive value (Goodnow, 1996). The sociocultural approach to learning provides a framework within which to consider the classroom contexts as relevant. Within this framework the classroom is considered a dynamic context in which (1) thought is mediated through artifacts -- such as different modes of classroom discourse; (2) the role of culture needs to be understood as a historical process -- such as the current changes in math education standards; and (3) where thinking needs to be conceptualized in terms of everyday practical activities - such as the wrap-up in the math classroom. Students' sense of their abilities develop in relation to the dynamic, active nature of this social context. Considering the current climate of change in math education, the classrooms in this project offered an opportunity to investigate girls' experiences in classrooms transitioning to more problem solving activities and student discussions about their math thinking.

Girls' Low Confidence in the Teacher Centered Context

The TC girls' low confidence about their abilities develops in a context of mixed messages about the expectations of student behavior and the value of certain kinds of math knowledge. The mixed message begins when the teacher's initiation focuses the wrap-up on the mechanics rather than the meaning of the prior problem solving activity. From this initiation, the discourse is further constrained by the recitation style of interaction in which the students can only respond to what the teacher asks about rote learning rather than discuss what they experienced about problem solving. Within the constraints of this recitation discourse students do not contribute to the discussion, they react to the teacher. There is no place for student generated ideas to be socially engaged. Students are engaged in the problem solving activity that is student centered and then they are constrained by the calculation wrap-up that is teacher-centered. This disparity in how thought is mediated in the TC context defines a classroom culture in which what is considered acceptable and valued learning behavior is unclear.

Relating discourse to activity. Prior to wrap-up, all the students are engaged in small group problem-solving activities, but the results of the SOME instrument showed that the TC teachers focused wrap-up on the mechanics, rather than the meanings, behind the prior problem-solving activity. This kind of talk is about following directions, recording results, and reporting the steps of rote calculations. Renkl and Helmke relate such "mechanics" of math to the promotion of basic arithmetic skills, rather than the promotion of higher order problem solving competencies (1992).

The TC teachers' recitation style discussions are therefore more like those that take place as demonstrations of rote learning and computation processes. The learning activity does not match the talk about that activity. Hence, the students are constrained to talk about their prior problem solving in terms of the computations embedded in the activities rather than in terms that allow expression of strategy testing and concept development.

In their theory of learning behavior, Fennema and Peterson (1985) argue that boys are not affected by the rules or "appropriate" behavior because their "transgressions" or problem solving behavior are encouraged by the teachers. Girls, on the other hand, have a more difficult time because their rule following is reinforced by the teacher. Although the present data did not measure students' adherence to rules in the classroom, I considered how the teachers' mechanical initiations as require a rule following student to talk about calculations, algorithms, and product rather than problem solving. It may be that the TC teachers' initiations therefore reinforce the girls' rule following behavior so that a problem solving culture does not develop in the wrap-up. Thus the context does not support the girls' confidence to engage in problem solving behavior because they are still following rules of calculation.

Other researchers support the idea that boys and girls differ in how they are rule based in class. Teachers are more tolerant of the boys when they take risks and offer probable answers or strategies to problem solving (Tartre & Fennema, 1995; Rathbone, 1989; Serbin et al, 1973) and are less tolerant of this behavior from girls (Leder, 1995; Orenstein, 1994; Fennema & Peterson, 1985). Meanwhile, girls are hesitant in this activity because they look for the "right answer" to show good student behavior (Walden & Walkerdine, 1990). Thus, in the TC context, the girls may be trying to make sense of the rules of discourse in order to participate in good student behavior, but this behavior may not be valued by the classroom culture (Walden & Walkerdine, 1985).

The findings suggest that in the TC context a lack of synchrony between activity and discourse about that activity impedes how the girls decipher what is appropriate and valued learning behavior. This may detrimentally affect the girls' confidence in their ability to engage in problem solving learning. A consequence of these teachers' initiations is the natural progression to a recitation script that follows. Although the teachers' training included leading student-centered group discussions, the TC teachers appear to rely on the use of traditional recitation style talk in their wrap-ups.

Recitation style discourse in the TC context. Results from the Sequence inventory established that the TC wrap-ups comprised mainly recitation (IRE) turns of talk between teacher and student. Remaining talk, that is talk that did not fall into IRE patterns, comprised other of the teacher talk categories. Thus all the student talk in the TC wrap-ups were responses to teachers elicitations, whereas the SC students engaged in all seven possible talk categories. Hence, the recitation style of the TC classroom context constrained students to talk in response to the teacher's initiation, which was always about the mechanics of computation.

The frequency of recitation exchanges results in a higher ratio of teacher to student utterance in the TC classrooms than is found in the SC classrooms. Hypothetically, a discussion purely comprised of recitation exchanges would be equally represented by: teacher elicitations, student responses, and teacher evaluations. The discussions would be two-thirds teacher talk and one-third student talk. In real classroom practice, such a configuration is unlikely because teachers also provide information, students ask questions, and students talk among themselves. Nevertheless, in three of the four TC classrooms the wrap-up discussions resembled this hypothetical three-part distribution, with over ninety percent of the discourse made up of IRE exchanges. With few exceptions, the TC teacher talk in these classrooms was evenly split between elicitations and evaluations, and the student talk is almost entirely responses.

Students engaged in this discourse may find more constraints on their talk about problem solving but may have more opportunities to behave as rule followers by following the recitation script: responding to the teachers' questions about calculations. This script constrains the rule following students to engage in responses about the mechanics of their math activity. The teachers' initiation emphasizes product rather than process, so that it is unnecessary for students to discuss meanings or explain their thinking.

The girls within these discursive constraints may be more socialized than the boys to behave as rule followers rather than risk takers who can discuss their problem solving strategies as suggested by Fennema & Peterson (1985) and Walden & Walkerdine (1985). By following the rules of recitation discourse the girls do not engage in the autonomous learning behavior that Fenemma and Peterson argue is conducive to problem solving (1985), behavior they argue comes more easily for the boys. Without the reinforcement and structure to engage in problem solving discourse, the girls' confidence in their problem solving ability may not develop. How they come to value, or to perceive value, in problem solving is brought into question as they are in a transitional state between activity that seems to value problem solving and discourse that seems to value computation.

Control and ownership of information. Although the teachers reported that they stress student-centered math activities, the ensuing discussion about that activity is incongruously controlled by the teacher. The recitation style of the TC wrap-up discourse also reflects the degree to which teachers relinquish control of the discussions to the students. The literature describes recitation style instruction as typical of pedagogical approaches in which the teachers know the answers.

Student-centered discourse can not proceed in a recitation script. Even when the teacher tries to initiate student talk it turns into IRE exchanges based on the teacher's idea of how things should proceed. The girls in the TC context lack the opportunity to share problem solving dialogue with their peers because they are constrained by the rules of recitation engagement with the teacher. In this context there is no risk taking, or meaning making involved for the student as long as he or she follows the recitation script. Walden & Walkerdine (1985) theorize that this process is detrimental to girls in problem solving classrooms because correct answers about basic arithmetic are no longer seen as "clever" or valued knowledge. Thus, even though the teacher encourages a certain math discourse through her use of the recitation exchange, that kind of math knowledge is not valued in the problem solving classroom. This reflects Goodnow's (1996) description of how cultural changes, such as the pedagogy in this case, affect what kinds of knowledge are valued.

Teachers' ownership of information is evident in recitation exchange not only in the quantity of teacher talk but in the quality of what is discussed. The teacher opens and closes each interaction. Thus, what is talked about derives from her initiation, and how that topic is valued derives from her uptake to the student's response. The student's role is not as contributor to what is learned but as reactor to what the teacher determines is worth knowing.

The teachers' ownership in this discourse reflects the findings from their scores on the Student Learning Process in Math Scale (SLPMS) that indicate their weak constructivist beliefs. Results of the first and fourth SLPMS subsections showed the TC teachers believe students learn math by receiving (rather than constructing) knowledge, and that the teacher's role is to present that knowledge. These beliefs are manifest in the control the teacher takes over what is said and how it said in the recitation interactions.

All students may doubt their abilities in this context because they do not have the opportunity to discuss their activities or to explore their meanings. However girls' low confidence in their abilities suggests they doubt their abilities more than the boys in this same context do. This may be because the boys are encouraged to transgress the "appropriate" behavior rules and generally receive positive feedback for problem solving behavior. In addition, boys' confidence may be related to their attributions of success as internally located.

Findings from the attributional measure showed the boys attributed their success in math to their own abilities, more than to effort, environment, or task.. However, the TC girls attribute their success to external forces (particularly the environment -- peers, teacher, the text) rather than to their own ability. Girls' sensitivity to their environment indicates a need to relate their thinking and learning to talk. Boys may be less invested in following rules to be "good students" because they confidently engage in learning behavior conducive to problem solving (Fennema & Peterson, 1985). Compared to girls, boys' confidence may be less related to whether or not they are seen as clever (Walden & Walkerdine, 1985).

<u>Pedagogical transitions to problem solving.</u> One way to understand how this lack of synchrony between activity and discourse occurs is to consider the

cultural process of mathematics pedagogy and the relevant development of artifacts in that process. From this perspective the TC classrooms are in partial transition from a focus on computation to a focus on problem-solving in math instruction. There are a number of reasons that this transitional state occurs. First, a traditional approach to mathematics instruction positions the more complex activities of problem solving after earlier established computation skills. Thus, in traditional elementary schools a transition from computation to problem-solving is common around the fourth and fifth grades[11]. Walden and Walkerdine (1985) theorized that the perception that girls do not do well in problem solving develops in this kind of transitional period during their education. This transition involves changes in what is considered "good student" or "clever" behavior.

Second, the current mandates in the teaching of math call for increased problem solving throughout all elementary math instruction (NCTM, 1997). Changes like this do not happen in an instant. Beliefs and practices in teacher education, in school curricula, and in teachers themselves change at different rates. Thus the teachers and students are part of an emerging pedagogical culture with changing values of problem solving and computational learning behavior.

A third way to consider the TC classrooms as contexts in transition is the role of these teachers as participants in a current math re-training program. They are adopting new instructional approaches to incorporate more problem solving and more student discussion. Although all the participating teachers have had a

[11] See Zalkower (1997) for an historical look at math curricula and the use of elementary school texts in the United States.

similar amount of experience in the retraining, the TC teachers are slightly older, and have had more years experience in teaching. Thus, they may be slower to adopt dramatic changes in their instructional approach, such as the relinquishing of control to the students, than the newer SC teachers.

These three perspectives on transition are meant to illustrate the conditions in which the TC classrooms are a context of unsynchronized activity and discourse. These periods of transition are what Walden and Walkerdine emphasize as the critical period in which the misperceptions of girls' abilities develop (1985). In the mechanical, process oriented wrap-ups, the girls are in the traditional learning behavior context where they can maintain the "good student" behavior of rote calculation by reporting the mechanical aspects of their prior math activities.

Summary. A recitation style of classroom talk about rote learning may be appropriate when rote learning is the relevant activity, but in the present project all the teachers were supposed to focus on student-centered problem solving activity rather than computation. However, what the TC students are asked to do in the problem solving activity is not supported by how they are asked to talk about this activity in the wrap-up afterward. While the activity appears student-centered and meaningful, the discourse is teacher-centered and didactic. This disparity may affect the girls' confidence in their abilities because the "cognitive value" and the "appropriate learning behavior" associated with the activities is ambiguous (Goodnow, 1996; Fennema & Peterson, 1985). The activity promotes student centered, risk taking, process oriented, learning behavior, but the discourse promotes teacher centered, rule making, product oriented learning behavior. Thus the culture of the classroom, and the inherent value of what Goodnow would call "worth knowing" is brought into question.

The girls in the TC classes may have lower confidence because the synthesis between activity and discourse is ambiguous. They are uncertain of the rules of appropriate and valued learning behavior and uncertain of their role as good students. On the one hand they follow the conventions of the problem solving activities: they work in small groups, they collaborate with peers, they create posters for presentation sharing of ideas at wrap-up. On the other hand, once wrap-up begins they are not asked to share these ways of knowing. Their wrap up discussions are constrained by recitation styles of talk in which identities fall into stereotypical roles: the all knowing teacher, the good girl student, and the risk-taking boy.

Girls' High Confidence in the Student Centered Context

In this section I discuss how girls' high confidence about their abilities develops in a classroom culture with a clearer message about the expectations of student behavior and the value of certain kinds of math knowledge. The strength of this message begins with the parity between activity and discourse. The SC teachers provide a discursive context in which the students can engage in "real talk" about their mathematics activity rather than in the didactics found in the TC context. In didactic talk each participant may report experience but there is no attempt among participants to join together to arrive at new understanding. "Really talking" requires an optimum setting for emergent ideas to grow. Real talk reaches into the experiences of participants and draws on the analytical abilities of each. Real talk includes " exploration, questions, argument, speculation, and sharing." (Belenky et al, pp. 145). From the teachers' initiations, the discourse is opened to the students to participate without the constraints of the recitation interaction. In this way, the wrap-up discourse is more like the prior problem solving activity: it is student centered, and it is focused on meanings and the sharing of students' ideas. This synchrony between the activity and the discourse about that activity is the first component of a context conducive to girls' strong confidence in their problem solving abilities.

Relating discourse to activity. Results from the SOME measure show that the teachers in the student-centered (SC) classrooms differed from the TC teachers by focusing the wrap-up on the meanings rather than the mechanics of the prior math activity. This kind of "meaningful math" talk refers to mathematical principles, basic concepts, and metacognitive questions. Renkle & Helmke (1992) associate this meaningful math construct with the promotion of problem-solving competencies as opposed to the mechanical tasks that promotes basic arithmetic skills (as in the TC classrooms).

The teachers' initiations of meaningful talk therefore reinforce the expectations of the prior problem solving activities. These expectations include learning behavior that is steeped in strategizing, recognizing patterns, sharing activities and ideas. The critical thinking, and self reflection fostered by this approach help to create a classroom culture in which students' thoughts, and ideas are valued components of the learning process (Goodnow, 1996).

In the SC classrooms, problem solving is salient in both the activity and the wrap-up discourse following that activity. This agreement between activity and discourse reinforces the kind of learning behavior that Fennema and Peterson suggest is needed for problem solving (1985). This classroom culture contrasts that of the TC classroom in its emphasis on problem solving over calculations: student-centered learning over teacher-directed instruction, risk taking over rule following, and students' ideas over a set of math topics determined by the teacher or the text.

Girls in this context engage in the problem solving discourse that is perceived as "good student behavior" (Walden & Walkerdine, 1985). The SC classroom culture supports and values the processes of problem solving by strengthening the activity with discussions about what that activity means. The SC students are expected to explore meaning. Students talk about their thinking, rather than report about their rule following. In this context girls are freed from the constraints of computation, mechanical, and rote activity. Thus, girls understand the acceptable learning behavior as different from the rule-following of computations. They do not break any rules by sharing their strategies. They do not risk their reputations as rule keepers because the rules are now changed to emphasize problem solving and the student ideas that develop from it.

Open discussion in the student-centered context. The results from the Sequence Inventory established that the SC classroom discourse was practically devoid of recitation exchanges between teacher and student. This is a sharp contrast to the TC wrap-ups. For example, in the SC classrooms IRE exchanges represented as little as five per cent of the wrap-up discourse, whereas in the TC classrooms the IRE exchanges represented over half the wrap-up discourse. Without the constraints of the recitation exchanges about rote learning, the SC students were able to engage in the discussion in many ways.

The SC wrap-up was characterized not only by more student talk than was found in the TC classrooms, but also by greater ratios of student to teacher talk. Without the constraints of the recitation exchange the students engaged in categories of talk beyond the responses to the teacher that characterized the TC student talk. Students initiated exchanges, asked questions among themselves and of the teacher, gave information to their peers and to the teacher; responded to each other, and followed up on their peer's utterances (uptake). The wrap-up discussions therefore were about the students' prior activity and their exploration of ideas rather than about pre-determined, teacher-controlled steps of algorithms and basic arithmetic facts.

This is talk about mathematics in which there is more than one strategy to consider, speculation is allowed, and math ideas can be debated. In the SC classroom context the students' experience of math develops in a culture of wrap-up in which students understand that they are to take part, to contribute, and engage themselves and one another in the meaning of mathematics.

Girls confidence in this context, as opposed to the recitation context, may be attributed to what Belenky and colleagues describe as "connected ways of knowing" (1986). Girls "connected ways of knowing" are fostered by the discursive sharing environment where ideas are related to personal experience, to others' ideas, and to the context in which they are discussed. Connected ways of knowing are supported by the social context of the wrap-up discussion, where girls can come to understand other people's experience and ideas, and become comfortable in reflection on their own ideas in comparison.

Control and ownership of learning. By initiating meaningful discussions and allowing the students to control much of the discussion, the SC teachers help create a classroom culture that values learning math as a process of thinking, sharing, and developing students' ideas. In this context all students claim ownership through participation in the discourse process. The SC teachers' ability to relinquish control of the discussion to the students may be related to the strength of their beliefs in the constructivist nature of mathematics instruction.

The teachers' discourse, and its affordance for more meaningful student participation reflects the SC teachers' beliefs about the constructivist nature of math learning. The SC teachers' scores on the SLPMS survey indicate that these teachers believe students construct ideas about math rather than receive them; that skills can be learned in relation to problem solving rather than in isolation from them; that the teacher's role is to guide students' thinking, not deliver math knowledge; and that math instruction should proceed according to students' understanding rather than a set sequence of math topics. These constructs indicate not only a willingness but a necessity to allow students agency in the math instruction.

The SC students' control of their math learning is evident not only in the greater proportion of student to teacher talk than that found in the TC group, but in the greater variation of categories of student talk. By allowing student initiations the teachers let the students control the talk about their own ideas. These topics then become the focus of debate, and are added to and built upon as they students negotiate their understanding.

Through the SC students' strong participation and ownership of information they come to identify themselves as thinkers, workers, and creators of knowledge for themselves and for each other. This kind of environment contrasts with that of a TC classroom in which the control and ownership of information belongs to the teacher, and the students are reactors to her actions, trying to figure out the rules of the environment rather than actively constructing them.

Pedagogical transitions into problem solving. In contrast to the transitional state of the TC classrooms, these SC classrooms appear to have adapted to student-centered problem solving so that there is greater synchrony between the problem solving activity and the wrap-up discourse. In the TC Context section above, I described the transition in terms of the teachers' ability to adapt to change. Compared to the TC group the SC teachers are younger and have had less experience teaching. Three of the four SC teachers also received the highest possible rating for participation in the math training program, where as only one of the four TC teachers received such a rating. This high rating indicates that in addition to regular attendance and participation in the training workshops the teachers became part-time staff for the training project - leading workshops for the subsequent generations of teacher trainees. Thus the SC teachers appear better equipped to adopt the pedagogical approaches conducive to student centered instruction, both in activity and in classroom discourse.

Summary. The girls with higher confidence, in the SC classroom context, are engaged in learning behavior where the activity and the discourse are related. They follow the conventions of the problem solving activity and then they engage in discourse about that activity. The teachers allow open discussions for the students to explore the meaning in their activities. By allowing this student-centered discourse the teachers show they value the students' ideas. Thus, students understand the appropriate learning behavior as having to do with the meaning rather than the mechanics of their mathematical activity.

Conclusion

The differences between the two classroom contexts indicate that the strength of girls' confidence in their problem solving ability is related to a combination of contextual factors. First, is the clear value placed on the problem solving as part of the classroom culture. This value can be made evident through a synchrony between activity and discourse about that activity. Meaningful student-centered activity requires meaningful student centered discussion. Second, such student-centered and meaningful discourse needs to be open enough for students to discuss their activities and ask questions among themselves. It can not take place in a traditional recitation style of interaction. In the open discussion, investigation of students' strategies and negotiations of meaning can develop. Third, the style of discourse affords certain ownership of information and control of learning. The recitation interactions are teacher dominant and leave no room for students' input into what may be discussed. The recitation interaction also precludes students from communicating with each other. The discussions remain centered on the teacher and the teacher's ideas about mathematics. On the other hand, where the teacher allows the wrap-up to progress according to the students' input, the value of student ideas is shared. In this context, without rules of recitation engagement to break, the girls participate as much as the boys and in similar ways --- sharing ideas, debating strategies, discovering patterns, and developing concepts about math. Here students' confidence in their abilities is high.

Limitations of the Study

Sample. A few factors contributed to the selection of this population. These teachers were available for the study because of their participation in the math training program, not by random selection. In addition, to eliminate school effect, I attempted to identify certain teachers in order to have different classroom talk styles from the same school. My choices were based on my five years of observations in their classrooms, a condition not easily replicable. The participating students for this project were all the students who returned the consent form, rather than a random selection of those available. This was because the class sizes were similar and almost all had the same rate of return for the consent form.

Generalizability. This sample of eight teachers is too small to make generalizations about classroom talk that are not biased by an individual teacher's style. A larger sample of teachers would provide a valid contrast between groups.

Similarly, five school are not enough to make school comparisons, but the matched pairs allowed me to discount school effect to some extent.

The present sample is best generalized to the population of teachers adopting this or a similar math curriculum with an emphasis on whole class wrap-ups after small group investigation based activity. Similar research in classroom discourse has been done in science classrooms (Reddy, 1994.) As math curricula across the country adapt to the new standards of the National Council on Teaching Mathematics, the generalizable population will grow.

Student math competency. I made certain assumptions about the math competency of this student population because standardized math test scores were unavailable for both individual students and individual classrooms. Instead, I combined the school level data from the standardized test scores, the use of matched classroom pairs, and information about the heterogeneity of student classroom assignment as appropriate criteria for comparability.

Audio and video intrusions. In spite of an initial positive attitude toward video, when it came time to collect the data some of the teachers resisted. Five of the teachers were concerned about who would see the video. One had scheduling difficulties that took him out of the classroom at the end of the year. Through my years observing these teachers I knew that the presence of recording equipment could be disruptive. The use of video equipment stilted the conversations of some teachers, and disrupted student behavior in some classrooms.

Recordings of the students' talk might have been better collected using wireless microphones for a sample of students, perhaps all the girls in two different types of classroom; or boys and girls in one type of classroom. Sheldon (1990) documents this method, and her use of "research vests" that carry the transmitter and mikes for students. She also employed an audio engineer, present at each session, who managed the high quality audio recordings because "recording audio with the mike that comes with a video camera does not produce research quality sound."

Teaching Style. These two groups may represent teaching styles that differ in more ways than simply the wrap-up discourse. The data used for this project represent a small part of the classroom culture developed for each group over the course of the year, and through the activities of subjects in addition to mathematics. Although I had observed these teachers' classrooms during the three years prior to this project, I did not collect reliable data to document the comparability of the problem solving activities that take place prior to wrap-up.

Observational Inventories. Capturing the differences in the wrap-up was difficult without recording many samples of the discussions. The observational inventories I used were adequate for recording the structural differences between groups but they could be improved with the use of unobtrusive recording equipment.

The SOME instrument was designed to inventory activity in the classroom as elicited by the teacher. I used it to inventory the teacher's utterances eliciting student activity. Therefore, this data does not include the students' utterances, which, in the SC classrooms, were very rich. In TC classrooms such observations were easily inventoried as almost all the students' responses and activities were teacher initiated. However, in the SC classrooms it was difficult to inventory these utterances because much of the activity was initiated by the students themselves and there was less teacher talk.

For example, students went up to the black board and presented their thinking and strategies, often without any teacher elicitation; or they engaged in student to student dialogue that would fall into the "meaningful" categories (discussions of principles and use of principles, sharing of ideas that were metacognitve), but this talk was not inventoried with the SOME unless the teacher joined in. Typically, the teacher made at least one comment about an "event" but this does not represent the richness of the students' activity accurately. A better measure of the meaningful activity would focus on the activity, regardless of how it was initiated, or tally the student talk in addition to teacher talk.

The Sequence inventory instrument used categories that were developed assuming teachers initiate most classroom talk. As in the SOME inventory, it was easy to use in the TC classrooms where the discussion was teacher directed. It was difficult in the SC classrooms because of the higher frequency of student initiated talk. For example, when three or more students engaged in talk about a strategy, most of the turns were coded as Student Information, and when the teacher joined in there was not a specific category to describe her input. It was not *uptake* --a follow up to a student response, and it was not *teacher information* -- intended to provide information. Most of these utterances were coded as *teacher response*, which might mislead the reader to believe that the students had asked a question, if the data were not considered as they occur in contingency with student elicitations.

Student Attributions of Success and Failure in Math. The design of this instrument may be too mature for this age. It was intended for thirteen and fourteen year olds. Although I used the developers' recommendations for altering the instrument for students in lower grades, these suggestions had more to do with the content of the math class (e.g., algebra versus multiplication) than it did with developmental concerns about students' understanding of the questions. The instrument called for the students to imagine particular success and failure scenarios. Trends in the results suggest that overall the students had a difficult time "imagining" failure, perhaps because they liked to think that they did not do poorly on homework or class assignments. They attributed more factors to success across the board. Boys in particular had very low attribution scores for imagined failures in any of the four categories - ability, task, effort, environment.

Coding. Subcodes of Uptake and Elicitations are available from the TIMMS research (1999) and could be used with the recorded data but were not included in the observational sequence inventory. Having not used them, I missed documentation of teacher uptakes that were just evaluations, which from my field notes over the previous four years were rampant in the TC classrooms and almost non-existent in the SC classrooms.

Implications

This research suggests that girls' participation in the SC classroom discussions allows them to have higher confidence in their math abilities. The implications of this finding are relevant to understanding both girls' early development and their later math learning, and approaches to classroom practice in general. Further research is applicable to the current state of reforms in mathematics education, the national focus on teacher education and evaluation, and to research in curriculum development for other domains.

Girls' Development

The implication for girls' development is that early math learning contexts may affect girls later math confidence and math choices. The introduction to this project highlighted the difficulty that girls continue to have in pursuing higher math education and math related careers despite their earlier success in mathematics. Since confidence is the key component to girls' success in mathematics (Bailey & Campbell, 1999; Fennema & Leder, 1983; Fennema & Peterson, 1985; Tobias, 1993), understanding the development of strong confidence is paramount to this success. Appropriate early learning environments could provide the necessary context for students to develop not only their math ideas, but also the necessary confidence in their abilities to learn that allows them to carry on with their math education, and with later careers.

Findings of the present study suggest that classroom talk limited to the products of computation is detrimental to girls' confidence. Although past research finds that girls excel in product oriented calculation work, the present findings suggest that when the math focus turns to problem solving, discourse centered on the mechanics of math can be detrimental. This appears to be the case even in classrooms in which problem solving investigations and small group work are stressed.

Current Reform in U.S. Mathematics Education

Findings from this project relate to how to operationalize ideas from the current math reform movement, such as increased problem solving and student discussion about math concepts. The differences in classroom discourse found in the present project relate to current mandates from the National Council of Teachers of Mathematics (NCTM, 1989; 1991; 1997) that place communication and discourse at the center of proposed reforms. Despite these mandates and teachers' beliefs that they are implementing these ideas in their classrooms, the present findings along with preliminary findings from the TIMMS study, suggest that not all teachers focus the math discourse on student-generated ideas about its meaning.

U.S. reform in a cross-cultural perspective. Stigler and his colleagues found evidence that Japanese teachers, more than U.S. teachers, orchestrate the kind of discourse called for in NCTM reform documents (Stigler, et al, 1999). *The Curriculum and Evaluation Standards for School Mathematics* states that the study of mathematics should include opportunities to communicate so that students can "reflect on and clarify their own thinking about mathematical ideas and situations" (NCTM, 1989, pp. 78). *The Professional Standards for Teaching Mathematics* promotes teaching standards such as "teachers should orchestrate discourse by posing questions and tasks that elicit, engage, and challenge each student's thinking" (NCTM, 1991, pp. 35). Students should "listen to, respond to, and question the teacher and one another," and "make conjectures and present solutions" (pp. 45, as in Stigler et al, 1999). The U.S. teachers in the TIMMS study did not engage students in this kind of classroom discourse. Rather, they stuck to more didactic discourse like the TC teachers of the present study. This distinction between the SC and TC teachers parallels the differences found between the Japanese and U.S. Teachers in the TIMSS study.

The Japanese teachers asked more describe/explain questions, and fewer yes/no questions, than U.S. teachers did. Student-generated solution strategies occurred more frequently in Japan than in the United States. The TIMMS authors explain this difference: the Japanese teachers more often have students struggle with a problem for which they have not been taught a solution, and then present the solutions they generated to the whole class. "Presentation and discussion of alternative solutions may provide a natural opportunity for engaging in the kind of mathematical discourse reformers are seeking to foster" (Stigler, 1999, pp., 123). The findings used to distinguish communicative groups in the present project suggest that analysis of the teachers' initiations can lead to further understanding of the patterns of discourse that follow. For example, the TC teachers' initiations might look like describe/explain questions as seen in the Japanese and SC teachers, but they are further defined as initiations about the mechanics, not the meaning, of the students' math activity. In the present example we saw that this difference limited the students to certain responses, and prevented them from "questioning the teacher and one another" as recommended above.

Further investigation into the similarities between the TC teachers and the U.S. teachers on one hand, and the SC teachers and Japanese teachers on the other, could help in understanding what constrains this kind of discourse and how changes in math practice, and the link between activity and discourse occurs.

Relating teachers' beliefs to their discourse. A second implication for mathematics reform is the link between classroom practice and reform recommendations based on teacher beliefs. In the present project teachers provided contradictory sets of beliefs about the nature of math instruction. This was evident in their self reported "constructivist" and "student centered" approach to teaching math when compared with the dichotomous results of the SLPMS. These latter data indicated that the TC teachers held less constructivist based beliefs about teaching math than the SC teachers. However, all the teachers self-described their math approach as constructivist and student centered. Their differences in math discourse appear related to their SLPMS beliefs but not their self reported style.

Similarly, in their discussion of U.S. reform from a cross-cultural perspective, the authors of the TIMMS study show that teachers in the United States are at odds with operationalizing the principles they share with the New Standards for teaching math.[12] Further investigation into the differences between the TC teachers and the SC teachers, and their beliefs and principles affecting their discourse decisions, could help in understanding how change in classroom practice occurs.

Teacher Education

The implications are crucial to teacher training. At the root of pedagogical transitions mentioned above is the readiness of teachers to guide student-centered learning. How teachers talk in the classroom, the didactics of classroom discourse for different classroom activities, should be included in teacher education. Teacher education programs should emphasize the role that teachers play in guiding classroom discourse so that it is less teacher centered and so that teachers are aware of the effects that their language use can have on students.

The findings suggest that even teachers comparable across a variety of indicators can differ significantly in their approach to classroom discourse. Teachers may make changes in their practice that reflect new student activity but if they then fall back on recitation style discourse about that activity, valuable opportunities for student development may be lost. Evaluations of whole group discussions can supplement existing indicators used in assessing teachers' performance.

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[12] For details of the differences in U.S. and Japanese teachers discourse and beliefs see chapter six in the TIMMS project (Stigler, et al. 1999).

Teaching experience. The findings from the descriptive data suggest that a variety of factors might influence teachers' ability to orchestrate student-centered discussions. The teachers who participated in this project were considered good, progressive teachers by their administrators. Teachers felt they had freedom to run their classrooms with little input from administrators, and few observational visits scrutinizing their daily practice. On the surface, they appear a comparable group, all trying to incorporate problem solving activities into their math lessons, and using small group work. Nevertheless, crucial distinctions were found in their practice that affect students, and understanding why these differences occur would benefit teacher education programs, and the student-teacher training paradigm. Although the present sample was too small to make statistical inferences about the teachers' differences, certain factors indicate areas for future research. One factor was the difference between the teachers' work experience in the two groups. Three of the four TC teachers had up to twice as many years of teaching experience than the SC teachers.

Teachers with more experience are possibly more set in their ways, and have fewer instructional models for making decisions about changes in their practice. Conversely, younger teachers, or teachers with less experience might be more open to certain practices, especially those supported by the propaganda of reform efforts and reinforced by their own teacher education.

Implications can also be made for pairing teachers in training with mentors. Seasoned teachers may offer years of experience in many areas but may be less motivated to incorporate new methods in their classrooms. Thus, they may not me the best models for student teachers who need to understand current initiatives. Teachers' beliefs about learning processes should be considered when seeking mentors or models of classroom practice.

Curriculum Assessment

Evaluations of curriculum often focus on availability and appropriateness of materials, the physical layout of work areas, and the use of small group or dyadic peer interactions. The presence of these instructional criteria are then measured against student performance. Meanwhile, student performance assessment has developed so that it increasingly entails the use of portfolios that give evidence of a student's work. Included in these assessments are the extent to which students can explain their mathematics activity and thinking. The present findings suggest that differences in classroom discourse are related to differences in students' confidence, hence opportunities to make such explanations about their thinking. Hence, the quality of a curricular approach should include a measure of the quality of the whole group discourse available to the students.

Gender in Other Curricular Domains

There are also implications for other domains of student learning. The kind of talk and speculation that marks discussions in the humanities and social sciences is similar to the discourse of the SC wrap-ups in this project. The use of student centered discussions may be explored as they relate to perceptions of female students' success in these domains, and lack of success in "harder" more technical sciences. In common are the interactions that allow the possibilities for more than one answer and that allow students to explore connections among their peers' and their own thinking. Findings in girls' confidence in this kind of discursive context can be used to further explore perceived gender differences in other domains.

Combined with findings in girls' "successful" domains these can also be used to investigate the theory that "girls' ways of knowing" are more related to connections over separation, understanding over assessment, and collaboration over debate. If the proper purpose of education (as suggested by Kohlberg & Mayer, 1972) is to assist students in moving them toward more mature stages of intellectual, epistemological, and ethical development, then the nature of these natural stages should be more clearly understood. The natural course of student development must not be fixed by "principles of scientific method...and rational reflection" (Kohlberg & Mayer, 1972, p. 475). Instead of imposing their own expectations and arbitrary requirements, educators can encourage students to evolve their own patterns of work based on the problems they are pursuing, and with respect for the knowledge that emerges from firsthand experience (Belenky, et al, 1986).

Conclusions

This study showed a gender difference in student math confidence in classrooms that were focused on student-centered discourse and classrooms that were not. Girls and boys in student-centered classrooms had higher confidence in their ability to learn math than did girls in teacher-centered classrooms. Boys in teacher-centered classrooms had higher confidence than their female classmates did.

Student-centered discourse was related to teachers' initiations of meaningful, rather than mechanical talk, and to teachers' ability to relinquish control of wrap-up discussions to the students. These abilities were found in teachers who held more constructively based beliefs about the nature of mathematics and how math is learned.

This student-centered discourse provides a learning context in which ideas are related to personal experience, to others' ideas, and to the context in which they are discussed. Girls' "connected" ways of knowing are fostered by this social context and their confidence in their own learning abilities is high.

Appendix A
Descriptive Tables

Table 14

School wide demographics* reported by the New York City Board of Education (1998)
(*percentages of students)

	*Above minimum performance level1	Race2 A H B W	LEP3	Poverty4	Immigrant5
City wide:	92	8 -37-36-18	19	74	12
School A	97	12-33-30-26	14	63	15
School B	94	0- 20-80- 0	11	99	3
School C	87	2 -48-51-.8	4	88	1
School D	87	.2- 91- 8-.4	56	100	13
School E	100	4- 38- 50-8	1	64	3

1 Score on city-wide standardized test for 4th Grade math
2 A-Asian, H-Hispanic, B- Black, W-White
3 Students with limited English proficiency
4 Student who meet requirements for Free Lunch program
5 Students who arrived in United States with in prior two years

Table 15

Teachers' ages, teaching experience, and education backgrounds

Teacher	Age	Yrs Exp.	Education	Training Rating*
1 Fiona	50	16	BA CCNY	2
2 Barry	38	10	MS Hunter	2
3 Ingrid	31	6	MA TC	2
4 Lou	46	14	MS CCNY	3
5 Ned	30	6	MS CCNY	3
6 Marsha	35	6	MA TC	3
7 Quentin	31	6	MS Hunter	2
8 Cathy	31	6	MA TC	3

* Rating given to teachers by the trainers from the Math program to reflect their level of participation in the training over two years, on a scale form 1-3.

Table 16

Teachers Scores on SLPMS *

*Beliefs about Student Learning Process in Mathematics Scale

Teacher	Scale I students construct or receive	Scale II skills in relation or isolation	Scale II Sequence of topics	Scale IV Role of the teacher	Average
Cathy #8	20	19	18	20	19.25
Quentin #7	14	23	17	15	17.25
Marsha #6	21	31	30	16	24.5
Ned #5	16	15	19	13	15.75
SC average	**17.75**	**22**	**21**	**16**	**19.12**
Lou #4	18	26	23	17	21
Ingrid #3	20	31	26	14	22.75
Barry #2	30	27	30	20	26.75
Fiona #1	44	45	35	41	41.25
TC average	**28**	**32.25**	**28.5**	**23**	**27.93**

* Numbers are total scores for each subscale. Range of possible scores for each subscale is 12 to 60, with a lower score indicating more constructivist viewpoint of mathematics learning.

** Developed by Peterson, Fennema, Carpenter, Loef (1989).

Table 17

Differences between TC and SC wrap-ups

Classroom		IRE interactions[1]	IR interactions[2]	Mechanical Initiations[3]	Meaningful Initiations[4]	Teacher talk[5]
TC	1	.54	--	.98	.02	.72
	2	.62	--	.95	.04	.73
	3	.57	--	.69	.31	.69
	4	.13	.35	.43	.57	.66
SC	5	.19	.11	**	**	.58
	6	.06	--	.22	.78	.29
	7	.12	--	.20	.80	.49
	8	.20	.26	.25	.75	.13

[1] Mean ratio of three-part recitation interaction to total talk during wrap up (SEQUENCE inventory)
[2] Mean ratio of two-part (teacher-student) interaction to total talk during wrap up.
[3] Mean frequency of mechanical initiations by the teacher (SOME inventory)
[4] Mean frequency of meaningful initiations by the teacher (SOME inventory)
[5] Mean ratio of teacher utterances to total talk
** Missing data

Table 18

Teacher talk* during wrap-up

Classroom		Elicitation	Information	Directive	Uptake	Response	Provide Answer	Other
TC	1	.49	.05	.09	.35	--	.04	--
	2	.46	.14	.05	.31	.003	.02	.007
	3	.47	.13	.09	.29	--	.02	--
	4	.42	.42	.02	.10	.006	.02	.004
SC	5	.35	.18	.21	.19	--	.01	.04
	6	.52	.20	.03	.22	--	.008	--
	7	.41	.18	.05	.25	.04	.02	.03
	8	.35	.19	.08	.40	.03	.003	.003

* Mean proportions of teacher talk categories in each classroom

Table 19

Student talk* during wrap-up.

Class room	Elicit	Inform	Directive	Uptake	Response	Provide Answer	Other
TC 1	0	.03	--	.01	.96	--	--
2	.007	.03	.73	--	.95	--	.002
3	--	--	--	--	1.00	--	--
4	.04	.25	--	.03	.68	--	--
SC 5	.03	.18	.009	.15	.49	--	.13
6	.13	.43	.003	.20	.21	.007	--
7	.06	.38	.03	.20	.37	.003	.02
8	.06	.24	.03	.13	.53	--	.005

* Mean proportions of talk categories for students in each classroom

Appendix B
Instruments

Teacher Beliefs in Student Learning Process in Mathematics (SLPMS Instrument)

Presented here in four subscales used for coding. Teacher instrument randomly mixed items and presented in Likert type scale.

SCALE I This scale is concerned with how children learn mathematics. This scale's continuum goes from the belief that children construct their own knowledge to the belief that children receive knowledge.

[Items are numbered in the order they appeared in the teacher's survey, and designated with a +/- to indicate reverse scoring.]

+ 12. Children learn math best by figuring out for themselves the ways to find the answers to simple word problems.

+ 25. Children can figure out ways to solve many math problems without formal instruction.

+ 26. Most young children can figure out a way to solve many mathematics problems without adult help.

+ 39. Most young children can figure out a way to solve a simple word problems.

+ 42. It is important for a child to discover how to solve simple word problems for him/herself.

+ 43. Children usually can figure out for themselves how to solve simple word problems.

- 2. Most young children have to be shown how to solve simple word problems.

- 4. It is important for a child to know how to follow directions to be a good problem solver.

- 10. Children learn mathematics best from the teachers; demonstrations and explanations.

- 13. To be successful in mathematics, a child must be a good listener.

-17. It is important for a child to be a good listener in order to learn how to do mathematics

-23. Children learn math best by attending to the teacher's explanations.

SCALE II The continuum for this scale goes from the belief that skills should be taught in isolation to the belief that skills should be taught in relationship to understanding and problem solving.

+3. Children should understand computational procedures before they master them.

+6. Children should understand computational procedures before they spend much time practicing them.

+21. Children should have many informal experiences solving simple word problems before they are expected to memorize basic number facts.

+27. Children should solve word problems before they master computational procedures.

+35. Children should understand the meaning of addition and subtraction before they memorize basic number facts.

+47. Time should be spent solving simple word problems before children spend much time practicing computational procedures.

-1. Time should be spent practicing computational procedures before children are expected to understand the procedures.

-30. Recall of basic number facts should precede the development of an understanding of addition and subtraction.

-32. Children should master computational procedures before they are expected to understand how those procedures work.

-37. Time should be spent practicing computational procedures before children spend much time solving problems.

-40. Children will not understand addition and subtraction until they have mastered some basic number facts.

-41. Children should not solve simple word problems until they have mastered some basic number facts.

SCALE III. The continuum for this scale goes from the belief that formal mathematics should provide the basis for sequencing topics for instruction to the belief that children's natural development of mathematical ideas should provide the basis for sequencing topics for instruction.

+8. The instructional sequence of math topics should be determined by the order in which children naturally acquire math concepts.

+9. The natural development of children's mathematical ideas must be considered in making instructional decisions.

+11. When selecting the next topic to be taught, a significant consideration is what children already know.

+14. The natural development of children's mathematical ideas should determine the sequence of topics used for instruction.

+28. In planning for instruction, it is important to know how children's mathematical ideas develop naturally.

+33. It is more important to use children's concept development in planning an instructional sequence than to use a mathematically determined sequence.

-5. The structure of mathematics should determine the sequence of topics which is used for instruction.

-19. The mathematical sequence must be considered in planning for instruction.

-22. The instructional sequence of math topics should be determined by the formal organization of mathematics rather than by the natural development of children's math ideas.

-29. It is more important to teach in a mathematically sequenced way than to use children's concept development in planning an instructional sequence.

-36. When selecting the next topic to be taught, one must consider the logical organization of mathematics.

-44. The structure of mathematics is more important in making instructional decisions than is the natural development of children's ideas.

SCALE IV. This scale is concerned with how mathematics should be taught. The continuum for this scale goes from the belief that instruction should facilitate children's construction of knowledge to the belief that teacher's should present knowledge.

+15. Teachers should allow children to figure out their own ways to solve simple word problems.

+20. Children should be allowed to invent ways to solve simple word problems before the teacher demonstrates how to solve the problem.

+24. Mathematics should be presented to children in such a way that they can discover relationships for themselves.

+31. Teachers should facilitate children's invention of ways to solve simple word problems.

+38. Teachers should encourage children who are having difficulty solving a word problem to continue to try to find a solution.

+48. It is better to provide a variety of word problems for children to solve.

-7. Teachers should exact procedures for solving word problems.

-16. Children should be told to solve problems the way the teacher has taught them.

-18. The best way to teach problem solving is to show children how to solve one kind of problem at a time.

-34. Teacher should tell children who are having difficulty solving a word problem how to solve the problem.

-45. The teacher should demonstrate how to solve simple word problems before children are allowed to solve problems.

-46. It is better to teach children how to solve one kind of word problem at a time.

Math Survey 1

On the following pages is a series of statements. There are no correct answers for these statements. They have been set up in a way, which permits you to indicate the extent to which you agree or disagree with the ideas expressed. Suppose the statement is:

		A	B	C	D	E
Example 1.	**I like mathematics.**	__	__	__	__	__

As you read the statement, you will know whether you agree or disagree.
If you strongly agree, check box **A**.
If you agree, even if you have some reservations, check box **B**.

If you neither agree nor disagree, that is you are not certain, then check box **C** for undecided. Also, if you cannot answer the question, check box **C**.

If you disagree, even if you have some reservations, check box **D**.
If you strongly disagree, check box **E**.

		A	B	C	D	E
Example 2.	**Math is very interesting to me.**	__	__	__	__	__

Do not spend much time with any statement, but be sure to answer every statement. There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make a choice.

THIS INVENTORY IS BEING USED FOR RESEARCH PURPOSES ONLY AND NO ONE WILL KNOW WHAT YOUR RESPONSES ARE.

Math Survey 1

A = strongly agree **B** = agree **C** = not sure **D** = disagree **E** = strongly disagree

		A	B	C	D	E
1.	Generally, I have felt secure about attempting math problems.	__	__	__	__	__
2.	I am sure I could do advanced work in math.	__	__	__	__	__
3.	I am sure that I can learn math.	__	__	__	__	__
4.	I think I could handle more difficult math.	__	__	__	__	__
5.	I can get good grades in math.	__	__	__	__	__
6.	I have a lot of self confidence when it comes to math.	__	__	__	__	__
7.	I am no good in math.	__	__	__	__	__
8.	I don't think I could do advanced math.	__	__	__	__	__
9.	I'm not the type to do well in math.	__	__	__	__	__
10.	For some reason even though I study, math seems unusually hard for me.	__	__	__	__	__
11.	Most subjects I can handle okay, but I tend to mess up math.	__	__	__	__	__
12.	Math has been my worst subject.	__	__	__	__	__

Math Survey 2 Instructions

You are going to read about an event which could have happened to you. In addition, you are going to see four possible causes of that event. You are going to respond to how you feel about whether the causes listed could really explain the event if it had happened to you. Read the event and then read each possible cause of the event carefully. Decide how you feel about each cause.

A = strongly agree **B** = agree **C** = not sure/can't answer **D** = disagree **E** = strongly disagree

Event Sample: A part of your homework was wrong.

Causes:	A	B	C	D	E
1. You just can't seem to remember to do the steps.	_	_	_	_	_
2. You were careless about completing it.	_	_	_	_	_
3. The part marked wrong was more difficult than other parts.	_	_	_	_	_
4. You were unlucky.	_	_	_	_	_

This event says, "A part of your math homework was wrong." Numbers 1, 2, 3, and 4 are possible causes for that event.

Look at number 1. Think about whether this could be a cause for the Event.

It says. "You just can't seem to remember the steps."

Do you STRONGLY AGREE or just AGREE? Are you NOT SURE, do you DISAGREE, or STRONGLY DISAGREE with that as a cause of this Event? Check the box labeled with the way you agree.

Now look at Number 2. "You were careless about completing it." Do you STRONGLY AGREE, AGREE, are you NOT SURE, do you DISAGREE, or STRONGLY DISAGREE with number 2 as a cause for Event A? Mark your answer in the appropriate box. Now mark how you feel about Number 3 and Number 4 as possible causes of this event.

Now, go to the next page and read the next event. Mark in the correct box how you feel about each cause for that event.

Math Survey 2

A = strongly agree **B** = agree **C** = not sure/can't answer **D** = disagree **E** = strongly disagree

Event: You got the grade you wanted on your report card for math.

		A	B	C	D	E
5.	The content of the class was easy.	_	_	_	_	_
6.	You spent a lot of time each day studying math.	_	_	_	_	_
7.	The teacher is good at explaining math.	_	_	_	_	_
8.	You have a special talent for math.	_	_	_	_	_

Event: You had trouble with some of the problems during school.

		A	B	C	D	E
9.	There was no time to get math help.	_	_	_	_	_
10.	You don't think in the logical way that math requires.	_	_	_	_	_
11.	You didn't take time to look at the book.	_	_	_	_	_
12.	They were difficult problems.	_	_	_	_	_

Event: You have not been able to keep up with most of the class in math.

		A	B	C	D	E
13.	Students sitting around you aren't paying attention.	_	_	_	_	_
14.	You haven't spent much time working on it.	_	_	_	_	_
15.	The material is difficult.	_	_	_	_	_
16.	You have always had a difficult time in math classes.	_	_	_	_	_

Math Survey 2 (continued)

A = strongly agree **B** = agree **C** = not sure/can't answer **D** = disagree **E** = strongly disagree

Event: You have been able to complete your last few math homework assignments easily.

		A	B	C	D	E
17.	The problems were more interesting.	_	_	_	_	_
18.	The effort you put into your homework earlier helped.	_	_	_	_	_
19.	You're a very able math student.	_	_	_	_	_
20.	You lucked into working with a helpful group.	_	_	_	_	_

Event: You were able to understand a difficult problem.

		A	B	C	D	E
21	The way the teacher presented math helped.	_	_	_	_	_
22.	You do better when you are challenged.	_	_	_	_	_
23.	You put hours of extra study time into it.	_	_	_	_	_
24.	The class had done one like it before.	_	_	_	_	_

Event: You received a low grade on a math test.

		A	B	C	D	E
25.	You're not the best student in math.	_	_	_	_	_
26.	You studied, but not hard enough.	_	_	_	_	_
27.	There were questions you'd never seen before.	_	_	_	_	_
28.	The teacher has spent too little class time on this unit.	_	_	_	_	_

General Information

Date of birth: (month_______(day)__________(year)__________

Check one: I am ( ) male ( ) female.

Check one: In my immediate family I am
( ) the only child.
( ) the oldest child.
( ) the middle child.
( ) the youngest child.

Including me there are ____________ children in my immediate family.

I have been in this school for __________ years (including this one).

How do you agree with the following statements? Check one answer for each.

A. In general, my mother understands the kind of math I have to do for school.
( ) Strongly agree. ( ) Agree. ( ) Don't know. ( ) Disagree. ( ) Strongly disagree.

B. In general, my father understands the kind of math I have to do for school.
( ) Strongly agree. ( ) Agree. ( ) Don't know. ( ) Disagree. ( ) Strongly disagree.

Check one: My parent(s) check my math homework
( ) every time.
( ) often.
( ) sometimes.
( ) once in a while.
( ) never.

Name any two people in your class that you'd like to get together with after school:

______________________________ ______________________________

Name any two people in your class that you'd like to work with in a math group:

______________________________ ______________________________

Sequence of Classroom talk

T or SF or SM or GR SX if unknown	Elicitation E Information I Direction D Uptake U Teach Resp TR	Student Elicitation SE Student Information SI Student Direction SD Student Uptake SU Student Response R	Provides Answer PA Other O

#	SPEAKER	UTTERANCE	TIMER	#	SPEAKER	UTTERANCE	TIMER
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

SOME

System for the observation of math in elementary school

Rater ____________ Tape Code ____________ Class activity ____________

Performance-oriented tasks: mechanical learning, learned by rote

Category	Code	Definition	Frequency
Factual knowledge	**1**	refers to single facts that can be retrieved from long-term memory (e.g., number facts, such as the result of 3 + 4; multiplication tables; " How many times does 5 go into 7?"; "Which is the numerator?")	
Procedure	**2**	pertains to procedures or algorithms that had already been taught in school (e.g., how one computes 23 + 35; "What are the steps...?")	
Product of a Procedure	**3**	concerns the outcome of a procedure or algorithm (e.g., the result of 23 + 35; different from factual knowledge in that it concerns compound numbers and more complex procedures.)	

Structure oriented tasks: meaningful learning, conceptual knowledge

Category	Code	Definition	Frequency
Principles	**4**	refers to explicit knowledge of mathematical principals and basic concepts (e.g., the law of commutativity; "Explain the big idea here.")	
Use of principles	**5**	concerns the application of mathematical principles (e.g., knowledge concerning whether 234 + 456 is the same as 456 + 234; "What kind of pattern are we seeing? Is there a shortcut?")	
Metacognitive questions	**6**	refers to questions that ask to think about how one thinks (e.g., "Who can explain why we get mistakes in subtraction?"; "Can someone say that in other words?")	

Appendix C
Transcript Examples

Teacher Centered

% Teacher #2 Fractions and decimals wrap-up

@ begin
@ participants: TEA teacher, STF female student, STM male student, STX unknown gender student, CLA group or whole class

*TEA: okay I see most of you have done this and done this well.
*TEA: so let us get started.
*TEA: before we uhm actually start to do that I just want to review with you the definition for the fraction the decimal and the percent.
*TEA: can anyone give me a uhm definition for what a fraction is?
*STM: it's not
*STM: ooh
*TEA: that wonderful definition that we seem not to remember?
*CLA: xxx
*TEA: James?
*STM: part of a whole.
*TEA: excellent James.
*TEA: part of a whole.
*TEA: does anyone remember what the definition for a decimal is?
*STF: a dot after the whole number?
*TEA: a dot after the whole after the whole number?
*TEA: okay I see what you're saying.
% counter = 016
*TEA: you want us to do a dot after the whole number.
*STF: yeah.
*TEA: well we can you put that as a decimal
% writing on the blackboard
*TEA: okay is that do you think that's like the whole thing of what a decimal is?
*CLA: no.
*TEA: cause I'll give you an example of what uh Tiarra said.
*TEA: she's saying that if I put a whole number here I put a dot there.
*TEA: that's a decimal.
*TEA: Tyrell do you agree with that?
*STM: um no.
*TEA: so is that enough?
*STM: um no
*TEA: why don't you give me an example of a what a decimal looks like Tiarra?
*STF: like you put the uhm
*STF: a decimal
*STF: and then you can put numbers
*TEA: give me an example please
*STF: xxx
% writing on board
*TEA: okay so what does that number tell me?
*TEA: who remembers what that number tells me?
*TEA: Ebony?
*TEA: do you remember?
*TEA: Lizette what are you thinking?
*STF: it's like um xxx

Teacher # 2

*TEA: why don't we take out our um sheets that we were working on tuesday?
% class is finding sheets in book
*STX: ooh
*TEA: what is a decimal?
*TEA: if you look at those sheets that we were using on tuesday
*TEA: what is a decimal?
*TEA: do each of those uhm figures have a decimal?
*CLA: yes.
*TEA: that represents them?
*TEA: yes they do.
*TEA: so what is a decimal?
*TEA: Tiffany?
% sounds of ruffling papers
*TEA: each figure was represented in what way three ways?
*TEA: Michael?
*STX: ooh ooh
*TEA: XXX?
*STX: um a decimal fraction and percent.
*TEA: a decimal a fraction and percent.
*TEA: so what's a frac what how do they relate?
*STM: um they're all the same thing but different
*TEA: they're all the same thing they all but they but they're both different.
*TEA: okay.
*TEA: can you tell me a little bit more than that?
*TEA: Josh?
*STM: there are different ways of percent?
*TEA: they are different forms but they're saying the same thing.
*TEA: so what two things
*TEA: does anyone remember what the fraction was for point ten?
*TEA: look on your paper you should be able to figure it out.
*TEA: we didn't do point ten but you should be able to figure it out.
*TEA: Jimmy?
*STM: ten out of a hundred?
*TEA: excellent Jimmy.
*TEA: so if we said this
% writing on blackboard
*TEA: ten out of a hundred.
*TEA: uhm can this be made smaller?
*TEA: Josh?
*STM: yes.
*TEA: how?
*TEA: I told a couple of people just as I was walking around.
*TEA: Shikara?
*STF: xxx
*TEA: no that's not what I told you first.
*TEA: Ebony?
*STF: cross out zeros?
*TEA: I'm going to cross out not zeros Ebony
*STX: xxx
*TEA: and why can I cross out those zeros?
*TEA: Rebecca?
*STF: because they're just a holding place.
*TEA: well their not only just a holding place but what

they're more than a holding place because this is real ten hundreds is real.
*TEA: okay? remember when I told you about this one?
% writing on blackboard
*TEA: okay this does hold a place we don't need it to say what it's going to be
*TEA: but uhm
*TEA: okay so this is one tenth.
*TEA: how do I say that as a decimal?
*TEA: Tiarra told us that before.
*STX: xxx
*TEA: and I can drop the zero and this is the same as this.
*TEA: so can someone now give me definition for a decimal?
% teacher waits for answer--counter at 073
*TEA: no one can give me a definition?
*TEA: Joshua?
*STM: maybe that it's smaller but still the same?
*TEA: how about looking at what we're doing.
*TEA: what am I doing here?
*TEA: does anyone see what I am doing?
*TEA: if you see what I'm doing then you should be able to give me a definition.
*TEA: and xxx said another form.
*STM: a fraction a decimal means a fraction that is in another form.
*TEA: thank you.
*TEA: excellent Joshua.
*TEA: all a decimal is is another way to represent a fraction.
*TEA: is this any different than this?
*TEA: no it's not.
*TEA: but is this a different form than this?
*CLA: yes.
*TEA: okay remember I told you when we did decimals
where don't we ever see a decimal when we're using something?
*TEA: which you don't use in school but I'm sure many of you use it at home.
*TEA: when you're doing your math homework?
*STX: in a calculator.
*TEA: in a calculator!
*TEA: you cannot use the fractions don't do you ever see a fraction?
*CLA: no.
*TEA: do you see a decimal?
*CLA: yes.
*TEA: yes!
*TEA: is this any different than this?
*CLA: no.
*TEA: it's just a different form.
*TEA: okay remember when I told you that we go from fractions
we start learning fractions in first and second grade?
*TEA: did you learn about decimals then?
*CLA: no.
*TEA: okay the next stepis to learn about decimals and the next step is to learn about percentages.
*TEA: because we're building on your knowledge
*TEA: we start down here we keep building and building until we get a larger picture.
*TEA: okay that's what this is.
*TEA: okay what was the definition I gave you tuesday for percent?
*TEA: James?
*STM: percent is a ratio of some number out of a hundred.

*TEA: thank you.
*TEA: a ratio
% writing on blackboard
*TEA: okay does everyone see the difference between these?
*CLA: yes.
*TEA: okay there is no difference between these numbers.
% writing on blackboard
*TEA: and this is saying ten one hundreths or one tenth
*TEA: this is saying point ten or point one its the same number ten percent.
*TEA: it's the same number okay
*TEA: it just depends on where you might see it.
*TEA: where might you see a number like this?
*TEA: where might you see a fraction?
*TEA: in everyday life where do we use fractions?
*TEA: Tiarra?
*STF: on recipies?
*TEA: on recipies.
*TEA: excellent.
*TEA: excellent.
*TEA: where might we see decimals in everyday life?
*TEA: Jimmy?
*STM: money?
*TEA: money!
*TEA: okay and where might we see percentages?
*TEA: Michael?
*STM: on tests?
*TEA: on tests.
*TEA: okay?
*TEA: so here we see this in recipies.
*TEA: here we see it in money.
*TEA: and here we see it in
*STX: on tests.
*TEA: on tests.
*TEA: any questions?
*CLA: no.
*TEA: copy this.
% counter at approx. 0119
% counter at approx. 0181
*TEA: if I count on this um square
*TEA: thirty three
*TEA: Rebecca where do I go?
*TEA: here
% tea pointing at something on board
*TEA: okay thirty three.
*TEA: so pretend I covered this whole little part here.
*TEA: okay what would be the next number if I wanted to
*TEA: double it?
*STX: sixty six?
*TEA: sixty six.
*TEA: okay and if I wanted to triple it?
*STX: ninety nine.
*TEA: ninety nine.
*TEA: how many pieces is that?

*STX: three.
*TEA: three.
*TEA: what fraction is thirty three over a hundred?
*TEA: Jeffrey?
*STM: three over ten?
*TEA: no.
*TEA: how many pieces did we do Jeffrey?
*STM: three.
*TEA: three.
*TEA: Jimmy?
*STM: half?
*TEA: half.
*TEA: how many pieces am I dealing with Jimmy?
*TEA: three
*TEA: if I was dealing with a half Jimmy
*TEA: what number would I have started at?
*TEA: would I have stopped at sixty six?
*TEA: what do you think xxx if I was doing it to a half?
*TEA: what's half of a hundred Saralee?
*STF: fifty.
*TEA: fifty.
*TEA: did I stop at fifty?
*CLA: no.
*TEA: I stopped at thirty three and I have three pieces.
*TEA: who remembers which part of the fraction the pieces
the number of pieces we're dealing with in the whole thing goes?
*TEA: Oh Tiarra?
*STF: the denominator.
*TEA: the denominator.
*TEA: three pieces one two three.
*TEA: and how many pieces am I dealing with in this problem?
*STX: one
*TEA: one two three.
*TEA: where did I stop my fraction?
*TEA: Amanda?
*STF: xxx
*TEA: no.
*TEA: where did I start it?
*TEA: thrity three.
*TEA: and then I went to sixty six and then I went to ninety nine.
*TEA: you showed me that there were three pieces.
*TEA: but where did I stop the first time?
*STF: at thirty three
*TEA: did I stop at sixty six?
*CLA: no.
*STX: ninety nine?
*TEA: did I stop at ninety nine the first time?
*STX: thirty three.
*TEA: where did I stop the first time Michael?
*TEA: what number is on the board Michael?
*STM: thirty three.
*TEA: thank you.
*TEA: so what part am I dealing with?

*TEA: how many pieces have I dealt with?
*TEA: James?
*TEA: James answer the question.
*STM: three.
*TEA: three pieces.
*TEA: and what does thirty three represent?
*TEA: what part of those pieces?
*TEA: James?
*TEA: listen to the question again.
*TEA: you're just giving me the answer I'm not asking for the answer.
*TEA: what part of the total pieces is thirty three?
*STM: xxx
*TEA: no.
*TEA: Lizette?
*STF: ten?
*TEA: did you listen to James?
*TEA: what did James just say?
*STF: xxx
*TEA: no he didn't.
*TEA: what did James just say Evan?
*STM: xxx
*TEA: no he didn't.
*TEA: what did James just say?
*STX: three.
*TEA: three.
*TEA: could you please listen to what he is saying.
*TEA: we don't repeat the same answers.
*TEA: Sellia?
*STX: xxx
*TEA: okay you know what?
*TEA: everyone write the number thirty three on your paper.
*TEA: and write the number sixty six.
*TEA: and write the number ninety nine.
*TEA: how many pieces do we have there?
*STX: three.
*TEA: three.
*TEA: and what number is on the board?
*CLA: thirty three.
*TEA: thirty three.
*TEA: what part of the whole is it that I'm dealing with?
*TEA: Jessica?
*STF: one?
*TEA: one.
*TEA: and that is the fraction.
*TEA: one whole.
*STX: one third.
*TEA: one third.
*TEA: okay this is something that you should know.
*TEA: when you see the number thirty three over a hundred
*TEA: another way to say that is one third.
*TEA: when you see the number sixty six over a hundred
*TEA: another way to say that is two thirds.
*TEA: okay?

*TEA: that's something that you should know.
*TEA: it's one of those things like twenty five over a hundred
*TEA: who remembers how we say that in a fraction?
*TEA: Amanda?
*STX: ooh
*TEA: Sellia?
*STF: one fourth.
*TEA: one fourth.
*TEA: and fifty over a hundred is what?
*STX: half.
*TEA: that's half.
*TEA: and who remembers what seventy five over a hundred is?
*TEA: Ebony?
*STF: three fourths.
*TEA: three fourths.
*TEA: those are fractions that you should always recognize
*TEA: because we always use them.
*TEA: this fraction here three fifths is not something we're always going to remember.
*TEA: it's not.
*TEA: okay let's look um at the next one twenty one percent.
*TEA: how would we say that as a uhm fraction?
*TEA: Saralee?
*STF: zero point twenty one?
*TEA: fraction.
*STF: oh a fraction is is twenty one over a hundred.
*TEA: twenty one over a hundred.
*TEA: okay and how do we say that as a decimal?
*TEA: Monica?
*STF: zero point twenty one.
*TEA: zero point twenty one.
*TEA: do we think that we can make this any smaller?
*TEA: twenty one over a hundred?
*TEA: no Rebecca why?
*STF: because twenty one and a hundred xxx
*TEA: they don't have any common numbers.
*TEA: okay what kind of number is this?
*CLA: even
*TEA: twenty one is even?
*CLA: odd.
*TEA: odd.
*TEA: and what are the factors of twenty one.
*TEA: who remembers?
*STX: xxx
*TEA: factors.
*STX: seven three
*TEA: seven and three and one and twenty one.
*TEA: seven and three can you put those numbers into a hundred ewenly?
*CLA: no.
*TEA: no.
*TEA: okay and let's see eighty five
*TEA: how do you say that as a fraction?
*TEA: Alvin do you know?
*TEA: Alvin look at the board.

Teacher # 2

*TEA: what have we been doing Alvin?
*STM: decimals.
*TEA: no we've been doing fractions.
*TEA: look at what we're doing.
*TEA: Michael?
*STM: um eighty five over a hundred?
*TEA: eighty five over a hundred.
*TEA: okay and how would we say that as a decimal?
*TEA: Cherise?
*STF: zero point eighty five.
*TEA: zero point eighty five.
*TEA: and does anyone think that we can make eighty five hundreths smaller?
*TEA: yeah?
*STX: xxx
*TEA: well I don't know.
*TEA: I'm asking you you said we can make it smaller.
*TEA: what do we think we might be able to divide into both eighty five and one hundred?
*TEA: what number might we be able to divide into both eighty five and one hundred?
*TEA: Michael?
*STM: five?
*TEA: excellent Michael let's see if we can do that.
% writing on blackboard--counter at 275.
*TEA: well I know that five goes into a hundred.
*TEA: okay does anyone know what I'm going to get?
*TEA: Jeffrey?
*STM: fifteen.
*TEA: fifteen?
*TEA: fifteen times five is not a hundred.
*STF: twenty.
*TEA: twenty.
*TEA: okay excellent Rebecca twenty.
*TEA: and let's see about five going into eighty five.
*TEA: how many times will five go into eight?
*TEA: Dartrell?
*STM: one.
*TEA: excellent Dartrell what's left over?
*TEA: Leslie?
*STF: three?
*TEA: three.
*TEA: how many times can five go into thirty five?
*CLA: seven.
*TEA: Lizette good hand raise.
*STF: seven.
*TEA: seven times.
*TEA: so can eighty five hundreds be reduced?
*CLA: yes.
*TEA: yes.
*TEA: any questions?
*CLA: no.
*TEA: no?
*TEA: okay.
*TEA: you should all have this already since most of you did it
*TEA: so let's open to page four hundred and thirty in our text book.

*STM: I have a question.
*TEA: yes John.
*STM: um how can you make the five go into eight?
*TEA: one goes into eight five times remainder three
*TEA: remember this short division?
*TEA: remember when I taught that very briefly?
% classroom noise
*TEA: cuatros cientos trienta
% classroom noise
*TEA: cuatro cientos trienta
*TEA: not four thirty
*TEA: not son las cuatro y media
*TEA: that's four thirty.
*TEA: okay?
*TEA: see the difference?
% counter at 0300.
% counter at 0360
*TEA: what would be the first thing you think we should put down?
*STF: three
*TEA: so put it down please.
*TEA: that's all I asked you to do.
*TEA: did I ask you to do anything else class?
*CLA: no.
*TEA: okay stop.
*TEA: how Shikara would I say that as a fraction?
*STF: three over a hundred
*TEA: excellent three over a hundred.
*TEA: Jaylene can three over a hundred be reduced?
*STF: no.
*TEA: no it cannot.
*TEA: excellent.
*TEA: and how would I say three precent or three over a hundred as a decimal?
*TEA: uh excuse me sir xxx
% tea addressing student--counter at 0371
% counter at 0376
*TEA: Adam says three over a hundred as point three.
*STM: xxx
*TEA: what do you think of the Tiarra?
*STF: point oh three?
*TEA: point oh three.
*TEA: okay remember there's got to be a place here Adam.
*TEA: remember this what place is this one?
*STM: that's um tens.
*TEA: tens
*STM: hundreds
*TEA: hundreds.
*TEA: how many places are we dealing with here?
*STM: xxx
*TEA: hundreds.
*TEA: point three would be thirty over a hundred.
*TEA: okay do you see that?
*TEA: okay let's do um
*TEA: let's do number ten

Teacher # 2

*TEA: okay how would I say that as percent?
*TEA: Lizette?
*STF: xxx
*STX: ooh
*STX: ooh
*TEA: Lizette what number is it saying right there?
*TEA: Lizette what number?
*TEA: Cellia?
*STF: seven hundred percent.
*TEA: seven hundred percent?
*TEA: okay?
*TEA: um Cellia why don't you come up to the board for a second?
*TEA: and show me what seven hundred looks like.
*TEA: not as a percent as anything
*TEA: a fraction as a decimal
*TEA: seven hundred
% student writing on blackboard
*TEA: excellent that what it looks like as a decimal.
*TEA: okay do you remember from the other day um Cellia
*TEA: when we were doing on the worksheet?
*TEA: you told me that this would be seven hundred percent.
*TEA: correct?
% tea addresses student
*TEA: is this number lar going to be larger than the number we're talking about or smaller?
*TEA: remember we
*STF: xxx
*TEA: this number here?
*STF: xxx
*TEA: this number is going to be what?
*STF: larger.
*TEA: larger.
*TEA: is this number a large number?
*STF: xxx
*TEA: can someone come up here and write this as a fraction?
*TEA: seven hundred?
*TEA: Jeffrey?
% writing on blackboard
*TEA: okay does this look familiar to you xxx?
*CLA: yeah
*TEA: three hundred seven hundred seven hundred three hundred
*TEA: so what would the percent look like?
*CLA: various comments
*TEA: so what would the percent look like?
*STF: seven percent.
*TEA: excellent Yolanda!
*TEA: seven percent.
*TEA: you know what seven hundred percent would look like?
*STX: like seven dollars.
*TEA: seven hundred uh seven dollars.
*TEA: remember when we were doing money the other day?
*TEA: when we did the dollar
*TEA: and anything less than a dollar was a fraction and anything more was going to be a larger percent than a hundred?

*TEA: this is a large percent of a hundred.
*TEA: remember we're dealing with hundreds.
*TEA: and when you get up to this what number is this considered to be?
*STX: one
*TEA: one but it's what supposed as a fraction?
*TEA: it's not a hundred.
*TEA: what did we discuss on tuesday?
*STX: xxx
*TEA: what?
*STX: a whole.
*TEA: a whole.
*TEA: okay a whole is represented by what percent class?
*CLA: a hundred
*TEA: a hundred percent!
*TEA: okay so then this number will be larger correct?
*TEA: okay?
*TEA: why don't you do at your desk
*TEA: examples seven
*TEA: nine
*TEA: twelve and twenty one.
*TEA: twelve I'm sorry
*TEA: twelve and fifteen.
*TEA: okay?
% tape ends at counter 0448
% video ends too
@ end

Student-Centered Group

@ Teacher # 6 --Franks and Buns

@ begin
@ participants: TEA teacher, STF female student, STM male student, STX unknown gender student, CLA group or whole class

*TEA: okay xxx why don't you start?
*STM: xxx first bun how many frank buns would you have left over?
*STM: and um how many how many um how yeah how many franks would you have left over and how many buns would you have
*STM: would you have left over?
*STM: and how many how many um how many franks and buns would you would you have to have?
*TEA: Richard?
*STM: um about how many packs of franks would you need and
*STM: how for three for three xxx twenty nine kids?
*STM: and buns.
*TEA: come on Keith?
*STM: how many franks um um um how many franks and how many buns would you need
*STM: and the um franks and the buns come in xxx and the franks come in packages of packages of eight
*STM: and the um um hot hot dogs buns come in packages of twelve.
*TEA: okay I think you want to write that on the board.
% writing on board
*TEA: and then three hot dogs
*STM: per person
*TEA: per person okay?
*TEA: per person.
*STM: and um you have to figure out um how um much frank
*STM: you have to figure out uh how many franks
*STM: how many packages of franks do you need for everyone
*STM: for it to be given out so everyone can get their um their franks.
*TEA: how many packages
*TEA: there's so much talking going on that I can't hear him.
*TEA: how many of packages of franks?
*STM: yeah.
*STM: do we need
*TEA: and buns or just franks?
*STM: buns hot dogs and buns
*STM: do we need
*STM: xxx and so um
*STF: oh that's um hotdog packages comes in packs of eight
*STM: xxx

% background noise until 040
*TEA: does anyone have anything to add?
*TEA: that's our investigation correct?
*CLA: yes.
*TEA: okay let's start our xxx
*TEA: we've got lots of work
*TEA: some people did it differently some people did it the same way xxx
*TEA: let me give you tape hold on one second.
*TEA: you can put it under my writing
*TEA: go put it under my writing
% tea giving instructions to a student
% there is background noise and instruction that I can't understand until approximately 052 on counter.
% two stf are at board explaining their work
*STF: alright um first we put
*STF: we already know that um twenty nine people eat three franks so three franks per person.
*STF: and we also know that they come in packs of franks come in packs of eight and buns come in packs of twelve and yada yada yada.
*STF: and so first we put two packs of eight together and we get sixteen franks in two packs.
*STF: and then we added another two packs and that would be sixteen and then we did xxx
*STF: and we did that because we got six packs of franks
*STF: and we added this xxx
*STF: so we did sixteen plus sixteen plus sixteen and that equals forty eight.
*STF: and I thought that would be a little bit too much
*STF: for just twenty nine people
*STF: and there would be a lot left over so
*STF: I did take away thirty two and that equals sixteen
*STF: and I added another sixteen and that would be thirty two
*STF: and from twenty nine to thirty two that would be um that would be um three left over and
*STF: so I did
% I think another student went up to the board at 069.
*STF: that would be sixteen plus sixteen plus sixteen plus sixteen that would be forty eight.
*STF: and we took away thrity two because
*TEA: because forty eight was too much
*STF: because forty eight was too many and that would be a waste of our money
*STF: so we took away thirty two that's equal to sixteen
*STF: that was too little

*STF: yeah that was too little so we added two more packs of franks that would make it thirty two.
*STF: and then we did forty eight take away thirty two
*STF: because it was a big number because it was twenty nine people we would be wasting franks
*STF: so we did sixteen plus sixteen
*STF: and it was better because thirty two was closer to twenty nine
*STF: so there wo.uld only be nine franks left over
*STF: and that was one pack
*STF: yeah that was one pack
*TEA: so that thirty two where you got the thirty two which was four packs of hotdogs
*TEA: you figured that was enough for everybody to have
*STF: that was the first time
*TEA: oh that was first time that everybody was going to have one hotdog.
*STF: so we did thirty two thirty two thirty two
*STF: that was four packs
*STF: each thirty two was four packs
*STF: because the first we knew that thirty two that everybody would get one
*STF: but everyone was going to get three
*STF: so we added thirty two three times and then we get ninety six
*STF: and then we did four plus four plus four that equals twelve packs of hotdogs
*STF: so that's how much
*STF: and well when we did um when we counted from twenty nine to thirty to thirty one to thirty two
*STF: we realized that that was was um three more um extra franks so we did three times three that equals nine and nine franks is one whole pack plus one extra frank.
*STF: xxx
*STF: and so now we're going packed with one extra with one extra xxx
*TEA: xxx
*STF: then we added um the left over frank and which was nine
*STF: which equal one pack and one left over frank
*STF: which equals which equals twelve packs cause xxx
*STF: xxx she started out with twelve and we added these together
*STF: and then with the leftover from these that equals one whole pack.
*STF: so instead of wasting her money and buying twelve packs with the leftover that's gonna equal thirteen packs
*STF: so then we put one pack back and not waste her money
*STF: and use the extras to make one whole pack.
*TEA: so how many packs am I going to buy?
*STF: you're going to buy twelve packs.
*TEA: okay xxx
*TEA: Erica?
*TEA: question?

*STF: um at the way beginning um y'all said that eight plus eight right you said that two sixteens was two packs right?
*STF: xxx
*STF: I thought it was four packs.
*STF: no cause it's eight packs in each
*STF: right franks come in packages in eight and eight plus eight equals sixteen.
*STF: and that's two packs of franks
*STF: I know eight plus eight equals sixteen and franks come in packages of eight
*% I couldn't understand this at counter 0114
*STF: no cause sixteen and sixteen make thirty two and that's four packs
*STF: one two three four
*STF: you don't get it?
*STF: xxx
*STF: xxx take away thirty two equals sixteen plus sixteen xxx
% counter at 0120
% counter at 0180
% two different students up at board
% in the middle of two students talking
*TEA: could we take a step back please
*TEA: you're telling me
*TEA: I'm really confused about this
*TEA: cause you're telling me
*TEA: in order for everybody to have three hotdogs we need to buy twelve packs and then there would be nine hotdogs left over.
*CLA: uh huh
*TEA: well I understand that.
*TEA: but nine hotdogs you're telling me is more than one pack
*STX: so you can put one pack of hotdogs back
*TEA: so I put one pack
*TEA: so instead of buying twelve
*TEA: then I'll buy eleven.
*STF: didn't she say eleven plus one pack?
% stf addressing another student
*STF: um yeah one pack of leftovers because nine is one pack
% counter at 0191
*STF: did you buy one pack of leftovers?
*STF: no it came with all of them xxx
% this conversation continues
% counter at 0197
*STF: obviously xxx she's gonna have one left over pack
*STF: she's gonna have nine left over franks and nine is more than nine is more than one pack
*STF: that's why I'm saying that xxx

*STF: she's only going to buy eleven packs
*STF: but she'll have one pack extra
*STF: ooh now I know
*TEA: alright um I know you did and and you did the bottom in a similar way?
*CLA: yeah
*TEA: oh you know what xxx?
*STX: okay
*TEA: you could kind of talk about the way that you did the whole thing.
% two different students at board
*STM: okay first we we knew that we wanted that we had twenty nine that we had twenty nine people in the class that would eat
*STM: so we xxx and we knew that each person would eat three franks so we tripled twenty nine and that gave us eighty seven.
*STM: and then xxx this is one pack
*STM: and twelve and twelve equal twenty four and that's two packs
*STM: plus another twenty four is forty eight is four packs
*STM: because because um twenty four xxx is six packs
*STM: xxx and then plus another twenty four is ninety six xxx
*STM: so when you reach ninety six xxx
*STM: so then you have one pack and one frank which is nine franks xxx
% counter at 220
*STM: this will be okay now xxx
*STM: xxx ninety six that's eight packs that's eight packs of twelve
*STM: so then you you will be eight whole
*STM: so you have to take away so you have to take away xxx
*STM: so you took away nine
*STM: xxx
% xxx (counter from 0228 through 0233)
*STM: so then after we after we added twelve to eighty four we
*STM: we're going to have one pack and one person
*STM: you're going to have one pack and one person left that would be our leftovers and xxx
*STM: and now you give three people xxx buns
*STM: you could give all everybody
*STM: you could give everybody
*STM: wait a minute
% various converations
*STM: oh yeah you could give you could give everybody you could give all the um children xxx extra
*STM: and then move on to the franks
*STM: and that would be eighty seven
*STM: xxx
*STM: so we would get one pack that is eight franks

*STM: so we did so we did eight times two
*STM: and that would give us sixteen xxx
*STM: that would be two packs
*STM: so you oh yeah xxx
*STM: four times eight then you get four times eight over here
*STM: and then and then we add it to the sixteen
*STM: and now and then
*STM: this is one pack
*STM: this is one pack
*STM: you added another pack and gave us sixteen franks
*STM: and xxx
*STM: and plus sixteen that would give us thirty two
*STM: and that's four packs
*STM: and plus one pack that would give us five packs would be forty.
*STM: and then we add sixteen which leaves us fifty six and that's seven packs.
*STM: and then plus another sixteen
*STM: and another sixteen gives us seventy two
*STM: nine packs
*STM: and then plus another sixteen gives us eighty eight
*STM: and you're going to have one frank one left over
*STM: you're going to have you're going to have one frank left over xxx
% counter at 269
*STM: xxx franks because each person's got to have three franks
*STM: each person's got to have three franks and three frank buns
*STM: so are we gonna throw away that extra one?
*CLA: no.
*STM: give it to the teacher.
% from 274 to 276 I couldn't understand
*TEA: um can we hear from the class for a second?
*TEA: Jannell?
*STF: xxx
% counter 278 to 283 I couldn't understand
*TEA: Saheem?
*STM: xxx with eleven packs xxx
*TEA: are there any questions for xxx and xxx?
*TEA: um Jannell and xxx you did yours very similarly right?
*TEA: I just want why don't you put yours up and why don't you say
*TEA: what you did that's similar
*TEA: and if there's anything different.
*TEA: put it somewhere where it's not covering anything else okay?

% from 293 to 297 students are woking at the board.
*STX: xxx

% counter at 0300
% counter at 0360
% another stm at board
*STM: cause
*STM: xxx
*TEA: well how did you notice that?
*STM: xxx
*TEA: oh
*STM: it was eighty seven
*STM: xxx
*TEA: how did you know xxx
*STM: each person gets three franks
*TEA: did you do that step
*TEA: of twenty nine times three or finding out how many hotdogs everyone needed?
*TEA: so Paul
*TEA: they said yes
*TEA: they did that step
*TEA: they just didn't write it
*TEA: actually it's over there
*TEA: I see it it's very light
*TEA: eighty seven hotdogs needed
*TEA: I see it you just didn't know how you figured it out
*TEA: okay alright
*TEA: good job
*TEA: any other questions for them?
*STM: they were saying that xxx
*STM: only I did first twenty nine times two
*STM: that was fifty eight
*STM: I added one more twenty nine
*STM: and that was eighty seven.
*STM: and then
*TEA: do you want to read it?
*TEA: it's very well written.
*STM: first we did twenty nine times two
*STM: that that two is two franks for each person
*STM: that was fifty eight franks
*STM: then we added then we added twenty nine more franks to fifty eight and
*STM: that was eighty seven franks all together
*STM: then we did ten packs of franks
*STM: that was eighty franks
*STM: that was less than eighty seven so we added
*STM: seven franks
*STM: so we put

*STM: we put in one more pack and that was eighty eight.
*STM: we had one left over
*STM: we had eleven packs to open
*STM: we did five packs of buns
*STM: that was sixty
*STM: then
*STM: we added two more packs to sixty buns
*STM: that was that gave us eighty four buns
*STM: that was less than eighty seven
*STM: we opened one more pack
*STM: that was ninety six buns
*STM: and there were eight packs that
*STM: that we opened
*STM: and there are nine leftovers.
*STM: nine leftover what?
*STM: franks?
*STM: buns?
*STM: eighty eight franks
*STM: and eleven packs
*TEA: okay so let's lets if we understand this
*TEA: who can say what George did in their own words?
*TEA: who could say what he did in their own words?
*TEA: uhm who hasn't spoken.
*TEA: Marcus you haven't in a while.
*STM: I think what he did is um twenty nine times three xxx
*STX: then um then he was trying to figure out how many packs is it that's eighty seven
*STX: so he did eight times ten which is eighty plus eight is eighty eight.
*STX: I don't know why he did twelve times five?
*STX: I did twelve times five because that means that xxx
*STX: twelve pack
*STX: twelve buns in each pack
*STX: and five packs
*STX: and that was sixty buns
*STX: oh.
*STX: xxx
*STX: he added another twenty four because he um wanted to get to eighty seven but he added twenty four because that's two packs of buns
*STX: so he added two packs of buns to that um sixty
*STX: and that made it eighty four so he
*STX: so that was so that was less than eighty eighty seven
*STX: so he had to add another pack of buns and that gave him ninety ninety six.
*TEA: did you want to say something Tanisha?
*STF: when nobody knew where that twelve times five came from

*STF: I said that twelve that twelve times five was the
buns cause that was the only thing that had twelve in it
% conversation from 455 to 459 I couldn't understand
*TEA: Erica?
*STF: that that five was a five pack
*STF: so you're saying like
*STF: like
*STF: the five the twelve was the five was five packs of buns
*STF: the twelve was like twelve buns inside each five pack
*STF: each pack.
*STM: there I put all the buns together
*STM: that was sixty buns that was less than eighty seven
*STM: so I added twenty four
*STM: that's two more packs
*STM: and that's eighty four which is still less than eighty seven so I added one more pack.
*TEA: does that make sense to you?
*TEA: I'm wondering
*TEA: looking at this work
*TEA: and I do have to say that there are very
*TEA: we don't really have time to show them but they they did it very very similar.
*TEA: it was Davisha
*TEA: Davisha your group did it and we put your work up
*TEA: Trevan your group did it
*TEA: and even Marquis your group did it a little bit too right?
*STM: yeah.
*TEA: we'll put your work up too just to show the difference.
% counter at 480
% counter at 553
*TEA: does anyone have any other comments?
% she's asking specific people if they have the work I think
*TEA: xxx you too?
*TEA: can you say it?
% student giving explanation
*TEA: right
*TEA: um xxx
*TEA: so that you
% tape ends there at 570
@ end

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