EXAMINING ROOTS OF THE GENDER GAP:
STUDENT PARTICIPATION AND TEACHER BEHAVIORS IN FIRST-GRADE MATHEMATICS LESSONS

BY

LEIGH ANN MINGLE

THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Educational Psychology
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2009

Urbana, Illinois

Adviser:

Professor Michelle Perry

Abstract

Females opt for careers in science, technology, engineering, and mathematics (STEM) fields far less than males. The purpose of this study was to examine potential roots of this disparity. Following Altermatt et al. (1998), the investigators took a careful look at girls' and boys' volunteering behaviors in 36 first-grade mathematics lessons. Contrary to previously reported findings, girls volunteered more than expected. Also, girls who volunteered frequently attempted to answer both high- and low-level questions. On the contrary, some boys answered mostly high-level questions whereas different boys answered mostly low-level questions. These early participation patterns and classroom activities may have repercussions far beyond elementary school by laying the foundation for persistent gender differences.

Acknowledgements

This project would not have been possible without the support of many people. My advisor, Michelle Perry has been unequivocally important in this process. She has guided me while still allowing me to follow my interests and instincts. Thanks also to Lucia Flevares who passed this project down to me and served as a wonderful consultant and co-author on this project. Great thanks to Meg Schleppenbach who served as my unofficial mentor when I entered the program and who still provides me with support and friendship. Also thanks to my committee members, Allison Ryan and Eva Pomerantz, who offered feedback and guidance throughout this project and in the classroom. And finally, thanks to parents, and many friends who listened to me chatter on about my research despite the many times they had heard it already. They have all been incredibly supportive and loving and I know they will continue to be in the future.

Table of Contents

Chapter 1

Introduction and Literature Review

Fourteen years ago, the American Association of University Women (AAUW) released *How Schools Shortchange Girls* (AAUW, 1995), a report on the gender inequities in mathematics and science education. This report reignited the drive for educational research to help explain these gender differences. Although some aspects of gender inequities in education have been studied thoroughly, there are still a host of unanswered questions. In particular, we are still faced with the persistent problem that girls opt for pathways in science, technology, engineering, and mathematics (STEM) fields far less than boys (e.g., Stewart, Malley, & LaVaque-Manty, 2007). The purpose of the investigation reported here is to shed some light on this issue and better understand potential causes of these gender differences in achievement in STEM fields.

What do these differences in STEM fields look like? As an example, in 2006, women made up only 17.4% of full professors in computers sciences and less than 10% in other STEM fields such as engineering (5%), mathematics (8.6%), and physical sciences (8.3%; NSF, 2006). Furthermore, the Congressional Committee on the Advancement of Women and Minorities in Science, Engineering and Technological Developments (2000) determined that only 29% of tenure-track women, compared to 58% of men, are likely to obtain tenure in STEM fields and only 23% of women, compared to 50% of men, are likely to achieve the post of full professor. We see these alarming trends even before women get to the workplace. According to the NSF's (2006) survey of doctoral recipients, in 2006, women received only 21.3% of doctorates in computer science, 20.2% of doctorates in engineering, 29.6% of doctorates in mathematics, and 29.0% of doctorates in physical sciences. This is compared to 71.3% of doctorates in psychology, and 45.7% of doctorates in other social sciences (NSF, 2006). This suggests that females are opting out of certain fields, thus never even having the opportunity to make it to the positions of highest power and prestige in those fields.

Despite the fact that girls indisputably fall behind when it comes to success in careers in mathematics and science (Kimball, 1989; Willingham & Cole, 1997; AAUW, 2008), girls appear to be doing fine in mathematics and science while in school, and even outperform boys (AAUW, 2008). Furthermore, the National Science Foundation (2005) noted that from 1998 to 2005 girls and boys enrolled in advanced placement mathematics classes at equal rates (AAUW, 2008). This leads us to ask: Where might these different patterns of performance come from?

Test-Taking and Risk-Taking

At least part of the explanation of why females do not enter STEM fields at the same rates as men rests in the fact that girls are scoring lower than boys on high-stakes tests, especially on mathematics sections. Girls score significantly lower than boys on tests of aptitude such as the SAT, ACT, and GRE (Willingham & Cole, 1997; AAUW, 2008). Gallagher et al. (2000), Kimball (1989), and others (e.g., Leder, 1992), add some light to this piece of the puzzle: they claim that boys take risks in solving novel and challenging problems, whereas girls tend to play it safe and expend efforts on the types of problems that have explicitly been taught. This difference may not seem important at early ages, but when faced with novel problems on the SAT, ACT, and GRE, boys would expend more effort in trying to solve these problems while girls would likely skip them and work on more familiar problems. Moreover, this risk-taking behavior in answering novel problems may result from higher confidence, which boys demonstrate in mathematics relative to girls (e.g., Fennema & Sherman, 1977; 1978). In any case, this difference in willingness to take on novel problems also helps to explain why gender differences do not appear in the classroom (AAUW, 2008) where tests are closely related to the curriculum taught, but appear on tests such as the SAT, ACT, and GRE that do not follow the classroom curriculum.

Reasoning that lower mathematics ability might be steering girls away from careers dependent on mathematics, Benbow, Lubinsky, Shea, and Eftekhari-Sanjani (2000) examined whether early mathematical ability is a predictor of later career choice and success outcome in a 20-year longitudinal study of mathematically gifted seventh-graders. They compared SAT scores of 9,927 gifted seventh-grade students and found a significant difference in scores favoring boys. Benbow et al. then followed 1,975 students and found that early differences in mathematics achievement predicted different educational and career outcomes, despite no gender differences in level of final degree or happiness with career choice and success level. They observed that males' careers were more heavily situated in the inorganic sciences and engineering whereas females' were observed more often in medical fields. Even among a group of gifted students, the differences revealed on high-stakes tests appeared to have long-lasting consequences, leading males and females to different career paths.

These differential patterns of performance on high-stakes tests and in ultimate career paths led us to question what factors may contribute to the emergence of these differences. Because there is no evidence that girls and boys exhibit early differences in grades or other measures of performance, researchers must turn to other information to understand how these later differences emerge. One such source of information could be the classroom participation of boys and girls.

Patterns of Participation

Participation is more important to student learning than simply indicating student involvement. As Turner and Patrick (2004) pointed out “participation is both a productive work habit, likely to contribute to learning, as well as evidence of student motivation to learn” (p. 1760). Thought of in this way, participation is an important marker – both a contributor and an outcome – of achievement in the classroom. As evidence of this, Good, Sikes, and Brophy (1973) noted that high-achieving students tend to be more active participants in the classroom than lower achieving students. High achievers also have more teacher contact, answer more questions, and receive more positive feedback than low-achieving students. Furthermore, Subotnik and Strauss (1995) found that classroom participation was a predictor of achievement on an Advanced Placement calculus test. In fact, the U.S. Department of Education has termed the lack of participation a “behavioral risk factor” (Finn, 1993) for school failure. Although the exact relationship between participation and achievement is not understood, participation has been shown at least to be one important factor of a rich classroom experience and, ultimately, achievement.

Some prior work has indicated interesting intersections between gender and classroom participation. Researchers (e.g., AAUW, 1995; Irvine, 1986; Becker, 1981; Cherry, 1975) have found that boys tend to participate more and receive more teacher feedback than girls. In high school geometry classes, Becker (1981) found that teachers asked boys more questions and gave them more feedback (see also Irvine, 1986); girls, in comparison, were quieter and participated less in the classroom. Furthermore, Irvine (1986) found that boys initiated more student-teacher interactions than girls. This indicates that boys are commanding more of their teacher’s attention.

Leinhardt, Seewald, and Engel (1979) found that these participation differences play out differently in different subject areas. They observed that, in reading, teachers made more academically centered contacts with girls, spent more cognitive time with girls, and gave more instruction to girls. In mathematics, the reverse was true: teachers made more academically centered contacts with boys, spent more cognitive time with boys, and gave more instruction to boys. Leinhardt et al.'s (1979) findings suggest that classroom interactions with teachers may be at least partially responsible for differences in achievement.

The Student's Role in Differential Participation Patterns: Volunteering to Participate

Although teachers clearly have much impact on the students' participation in their classrooms, these differences in participation across genders cannot be pinned entirely on the teachers' partiality. Instead, it is likely that differences in teacher contact are a function, at least in part, of the students' willingness to participate. Altermatt, Jovanovic, and Perry (1998) operationalized this as student volunteering. Altermatt et al. (1998) studied 165 middle-school students in six science classrooms to determine if boys or girls volunteered to answer questions at different rates and if rate of volunteering was related to the rate of teacher call-ons. Consistent with previous findings (AAUW, 1995; Becker, 1981; Cherry, 1975), Altermatt et al. (1998) found that, overall, boys accounted for the majority of all student responses to teacher questions. However, Altermatt et al. (1998) also found that boys volunteered to answer questions 1.59 times more frequently than girls. In fact, of the 17 most responsive students, 14 were boys. When they volunteered, girls were actually called on slightly *more* than would be expected. In fact, Altermatt, et al. found that differences in classroom participation were a function of students' volunteering: teachers were responsive to students and not biased. These findings indicate that teachers were calling on students who volunteered and the observed gender bias in whom teachers call on is a product of students' differential volunteering.

Given the important role of classroom participation in student achievement, combined with results that males volunteer more and ultimately succeed more than girls in mathematics and the mathematics-based sciences, we set out to examine some of the potential roots of these differences. Thus, we turned our attention to first grade, when most students have their introduction to formal mathematics instruction, and also have the opportunity to be socialized into becoming students of mathematics.

Because very little research has looked at the early causes of gender differences, we chose to look at girls' and boys' volunteering behavior in first grade. We observed the students at the beginning, middle, and end of the school year. The purpose of this investigation was to identify the emergence and socialization of classroom participation and how this socialization differs between boys and girls. We also wanted to know what the volunteering habits of these students were before they had a chance to be socialized and influenced by teacher expectations and how these habits potentially changed over the course of the year.

To investigate the previously observed boys' inclination to attempt challenging problems, and girls' relative aversion to these, and following previous work (e.g., Altermatt et al., 1998; Leder, 1993), we also paid attention to the level of challenge in each question asked by the teacher. We then noted who volunteered to answer these more challenging questions, and whom the teacher selected to provide the response in front of the class. We argue that these are potentially powerful socializing moments. Students may learn more than the mathematics in first-grade mathematics classes; they may also learn what counts as appropriate behavior in mathematics class.

Chapter 2

Method

Participants

Four experienced first-grade teachers and their classes participated in the observations. All four had taught for at least 10 years and three had taught for more than 20 years. All four classrooms were in public schools in a small urban community; the classes averaged 22 enrolled students. Student participants reflected the general socioeconomic and ethnic makeup of the community: one school had 26% and the other had 37% of students from non-White backgrounds and both schools had more than 30% low-income students (32% in one and 42% in the other school).

Data Sources

We recorded on video a total of 36 mathematics lessons, 9 for each of the 4 classrooms. We recorded lessons in each classroom at three different points during the school year (fall, winter, and spring) to capture any longitudinal variations in classroom routines[1]. Fall lessons were taped in middle to late September or early October, winter lessons were videotaped in late January or early February, and spring lessons were observed in middle to late May. In each season, classroom lessons were videotaped for three consecutive days. Two cameras were present for each day of recording, one focused on the students and one focused on the teacher. This allowed us to accurately capture which students were participating at each point in the lessons.

Lesson topics were typical for first-grade, including addition, subtraction, geometry, time, measurement, and fractions. Lessons ranged in time from 30 to 45 minutes. For purposes of analysis, we focused only on whole-class portions of the lessons (i.e., not including time when students were involved in individual seatwork). Whole-class portions of the lessons ranged in time from approximately 11 minutes to 44 minutes.

We conducted semi-structured interviews with each of the teachers in December. The purpose of these interviews was to gather information about the teachers' perceptions of their teaching and student learning in their classrooms. During these interviews, teachers spontaneously made some comments concerning gender and participation. Because these were not systematic, we do not include these in the Results. Instead, as these comments inform our concluding reflections, we include these in the Discussion.

Coding

From the video data and resultant transcripts, we looked for several features of classroom interaction. To begin, we noted each question the teacher addressed to the entire class. We call these, following both Altermatt et al. (1998) and Brophy and Good (1974) "open questions." We used these questions (and not the closed questions, the type of questions that were addressed to one student in particular) to examine the issue of student volunteering because students could volunteer only for these questions.

After identifying the open questions, we noted the students who volunteered and were called on for each of the questions. We defined volunteering as a hand raise indicating the student's willingness to attempt the problem and we defined call on as the teacher choosing a student to answer the question.

Next, we separated conceptually high- and low-level questions, so that we could determine whether boys or girls were volunteering for the more mathematically challenging questions, and whether teachers were calling on girls or boys more frequently for these challenging questions.

To examine high- and low-level questions in our data, we began with definitions from previous research that differentiated convergent and divergent questions from memory questions (e.g., Good et al., 1973) and process from product questions (e.g., Becker, 1981). With these frameworks in mind, one of the authors began by going through several of the lessons and selected those questions that she would consider high-level (also see Leder, 1993). We used this informed initial pass through a portion of the data to frame a systematic coding scheme to identify high- and low-level open questions. Although we could have followed others' distinctions between high- and low-level questions, we decided to develop our own system because, unlike others, we focused on first grade. It is possible that the specific types of questions may differ, based on the age of the students and their capablilities for responding to these questions. Ultimately, the high-level questions included each the following types of questions:

- comparisons to previous ideas (e.g., How is this different from before?),
- questions about procedures (e.g., Do you have any ideas how to do this?; Do you have a different idea of how to do this problem?; How did you get that answer?; or Why am I doing this?),
- opinions about procedure and an explanation of that opinion (e.g., Do you agree or disagree with your classmate, why?),
- asking for a definition of a concept in the students' own words rather than recall (e.g., Can you explain this concept?).

Low-level questions were defined as questions that asked for:

- recall from previous lessons, the book, etc.;
- asking for an alternative when it is problem-related but not necessarily mathematically relevant (e.g., “What other things could we count?”);
- questions about rote or known procedures such as about how to write equation parts or parts of a solution (e.g., Where would I put the number, sign, etc.) or about sub-procedures rather than the entire concepts of the problem (e.g., What would you write down/do first, next, etc.?); and
- calculations.

A second researcher coded a random 25% of the lessons (9 lessons) and reliability was computed on these lessons. The two coders had a simple agreement of 95.3% and a Cohen’s kappa of .75. All disagreements were resolved through discussion.

Chapter 3

Results

Overview

The four teachers in our sample asked a total of 449 open questions in 36 lessons (9 lessons for each of the 4 teachers). Students volunteered to answer these questions 2100 times and were called on 441 times. Students in Teacher A's classroom volunteered to answer questions 188 times and were called on 72 times for 72 questions. Students in Teacher B's classroom volunteered to answer questions 515 times and were called on 121 times for 121 questions. Students in Teacher C's classroom volunteered to answer 898 times and were called on 170 times for 182 questions. The disparity between the number of times a student was called on and the number of questions was a product of the teacher ultimately answering their own question, but not before students had begun to volunteer. Students in Teacher D's classroom volunteered to answer 499 times and were called on 78 times for 74 questions.

In the remainder of the Results, we first present our results from whole-sample analyses, in which we pooled the four classes over the 36 observations and looked for patterns of participation and teacher responsiveness. Next, we present our results from classroom-level analyses, in which we examined classes separately to account for differences in the proportions of boys and girls in the four classrooms. Finally, we present our examination of whether the level of the question (high vs. low) impacted gendered classroom behaviors.

Whole-Sample Analyses

We conducted several analyses on the entire sample to get a general sense of what first-grade teachers and their students did in asking and responding to mathematical questions. We asked two questions: (a) did boys or girls volunteer more and (b) how responsive were teachers were to student volunteering by boys and girls? We present the results to these inquiries in turn.

To determine whether the first-grade boys or girls in our sample volunteered more, we calculated the total volunteering across all lessons, by gender. We found that girls volunteered more than boys: girls' volunteering accounted for 57.6% of all student volunteering and boys' volunteering accounted for 42.4%.

To determine responsiveness, we calculated the total call-ons across all lessons, by gender. We found that teachers called on girls more than boys: girls were called on to answer 57.5% of the total questions and boys were called on to answer 42.5%. Thus, the girls were also being called on to answer questions at about the same rate that they were volunteering to answer these questions. The differences between genders in both volunteering and call-ons were significant. Using a paired samples *t-test*, we found that girls volunteered significantly more, $t(270) = -2.92$, $p < 0.004$, and were called on significantly more, $t(270) = -2.20$, $p = .004$, than boys.

The results of the *t-test* indicate that, on average, the girls volunteered more than the boys in this sample. We were also interested in outliers. In other words, we wondered whether the students who were persistent at volunteering were more likely to be girls or were more likely to be boys. To examine this issue, we noted which students volunteered the most. The top 5 volunteers were all female. Expanding to the top 10 volunteers across all seasons (in the end, 11 were examined because the students ranked 10th and 11th were tied), we found that 7 of the top 11 volunteers were female and 4 were male.

Analyses by Class

The analyses conducted thus far were conducted on the entire sample, and thus not sensitive to the gender make-up of the individual classes. To account for potential differences in volunteering that could be spurred by a disproportionate number of girls versus boys in each class, we examined differences in volunteering in each of the four classrooms, taking into account the number of boys and girls who were present in each class for each observation.

Volunteering relative to the proportion of male and female students. To find out if girls or boys volunteered more given the proportion of each gender in the classroom, we conducted a χ^2 goodness of fit analysis. Following Altermatt et al. (1998), we multiplied the total amount of volunteering across all open questions in the classroom times the proportion of each gender (boys versus girls) in the classroom to find the expected values for each cell. These values were compared to the total observed amount of volunteering per gender in each classroom.

To clarify, we present the results of this analysis from Teacher A's classroom. In Teacher A's classroom, the total number of times all students volunteered for all open questions was 188, and girls made up 57% of the students in the classroom. Therefore, to determine the *expected* number of times a girl should volunteer in Classroom A, we multiplied 188 times 0.57. In other words, we would expect girls to volunteer 107 times in Teacher A's classroom. This is compared to the 119 times a girl actually was observed to volunteer.

For the volunteering rates across all classrooms, the expected values for each classroom were added together and then compared to the number of times each student volunteered across all the classrooms. We found that, across all four classrooms, girls volunteered more than expected. We conducted this analysis with all four classrooms and found that, across all four classrooms combined, girls volunteered significantly more than expected. Follow-up analyses indicated that this result was significant only for classrooms C and D, The details of this analysis are displayed in Table 1.

Teacher responsiveness relative to the proportion of male and female students. After looking at the expected versus actual volunteerism, we then wanted to compare the call-on rates of boys and girls given the proportion of boys and girls in each of the classrooms. To find the expected values for each cell, we multiplied the total number of open questions for each classroom by the proportion of each gender in the classroom. Again, using Teacher A's classroom as our example, Teacher A asked a total of 72 open questions and girls made up 57% of the students in the classroom. Therefore, we would expect for girls to be called in Classroom A for 72 times 0.57 questions, or 41 questions. This is compared to the 46 times a girl was observed to be called on.

Overall, we found that the teachers called on students no more or less than expected, given the proportion of students of each gender in the classroom. The complete results of these analyses for each classroom can be found in Table 2.

Teacher responsiveness relative to student volunteering. Given that neither girls nor boys were called on more than expected (based on the proportion of each gender in the classrooms), we then wanted to know if boys or girls were called on more than expected given the amount of volunteering done by students of each gender in each classroom. To determine the expected values of each cell for these analyses, we multiplied the number of open questions asked by the proportion of the total volunteering done by each gender.

For example, in Teacher A's classroom, 72 open questions were asked across all lessons, and the proportion of the total volunteering done by girls was 62%. The proportion of the total volunteering done by each gender was found by dividing the amount of volunteering done by students of each gender by the amount of volunteering done by all students. The expected value for girls being called on based on their volunteering rates in Teacher A's classroom is 72 times 0.62 questions, or almost 45 questions. This is compared to the 46 times a girl was observed to be called on.

Overall, we found that teachers called on students of each gender as expected given the amount of volunteering done by the students of each gender. The results of these analyses for each classroom can be found in Table 3.

Question-level Analysis

After looking at volunteering in general, we wanted to look more specifically at the kinds of questions for which boys and girls volunteered. We examined whether boys or girls volunteered more for high- or low-level questions. Likewise, we examined if any of the teachers were differentially responsive to boys or girls for high- or low-level questions.

Volunteering for high- and low-level questions relative to the proportion of male and female students. First, we analyzed the rate of volunteering for each level of question done by each gender. To determine the expected values for each level of question, we multiplied the proportion of each gender in the classroom times the total amount of volunteering done by all students on that level of question.

For example, for high-level questions in Teacher A's classroom, all students volunteered a total of 42 times and girls made up 57% of the students in the classroom. Therefore, we would expect girls to volunteer to answer approximately 24 high-level questions (multiplying 42 times 0.57 = 23.94).

Overall, we found that girls volunteered more than expected for low-level questions, and both boys and girls volunteered as expected for high-level questions. Teachers C and D's lessons had significantly more girls volunteering for low-level questions than expected, and we found effects in the same direction for Teachers A and B. The results from these analyses for both question levels in each classroom can be found in Table 4.

Teacher responsiveness to high- and low-level questions, relative to the proportion of male and female students. After analyzing the volunteering rates for each gender on both levels of open questions, we looked at the call-on rates based on the proportion of each gender in the each of the classrooms. To determine the expected value for this analysis, we multiplied the number of questions asked at each level in each classroom by the proportion of each gender in the classroom.

For example, Teacher A asked 20 high-level questions across all lessons and 57% of the students in the classroom were girls. Subsequently, to find our expected number of girls who should be called on for high-level questions in Teacher A's classroom, we would multiply 20 times 0.57 (or called on a total of 11 times). These analyses showed no significant differences in any classroom between the observed and expected rates of teacher responsiveness for each gender on each type of question. The results for each classroom are displayed in Table 5.

Teacher responsiveness to high- and low-level questions, relative to student volunteering. We then looked at the call-on rates for each level of question based on the proportion of each gender that volunteered in the classroom. To find the expected value for these analyses, we multiplied the total number of open questions of each level in each classroom times the proportion of the total volunteering for each question level done by each gender in the classroom.

For example, Teacher A asked 20 high-level questions and, overall, girls volunteered for high-level questions 67% of the time. Therefore, to derive the expected number of times the teacher should call on a girl in Classroom A for high-level questions, we would multiply 20 times 0.67. We did not find significant differences. The results for each classroom can be found in Table 6.

Gender Differences in Student Volunteering Rates

After we found out that girls volunteered for low-level questions more than expected across all classrooms, in a close examination of the data, we noticed that certain girls seemed to volunteer more than others for high-level questions. From this, we suspected that a small group of girls may have been responsible for most of the volunteering for high-level questions, rather than the volunteering being spread out across all the girls in the classroom. To investigate this issue, we ranked each student's volunteering in each classroom. The ranking was based on both question level and gender. In other words, we had four separate rankings: girls who volunteered for high-level questions, boys who volunteered for high-level questions, girls who volunteered for low-level questions, and boys who volunteered for low-level questions. We then looked at the percentage of volunteering done by the 25% of students in each ranking. Recall that the students in Teacher A's and B's classrooms switched classrooms over the period of observation; therefore, we collapsed these students' volunteering rates (as if they resided in one classroom) so we could get a complete picture of each student's volunteering. Overall, the top quarter of the students made up over 40% of the volunteering for each group, and in many cases, the top quarter of volunteers made up over half of all the volunteering. These results can be found in Table 7.

After analyzing the rankings of the students in each classroom by gender for each level of question, we noticed that the girls who did the majority of the volunteering for the high-level questions were indeed the same girls who did the majority of volunteering for the low-level questions in each classroom. Conversely, we noticed that the boys who did the majority of the volunteering for the high-level questions were not the same boys who did the majority of the volunteering for the low-level questions in each classroom. To test this observation, we correlated the amount of volunteering done by each student for the high- and low-level questions. We found evidence to support our observations: the girls' volunteering for high- and low-level questions was significantly related, and this was true across all classrooms (with the exception of Classroom D). We did not find the same relation for boys. These results can also be found in Table 6.

Summary

Our analyses show that although the teachers were responsive to the volunteering rates of the students, the students volunteered at very different rates. Girls volunteered more than expected given the proportion of girls in the classroom. Interestingly, girls also volunteered more than expected given the proportion of girls in the classroom for low-level questions across all classrooms. We also found that a subset of the students in each classroom did the majority of the volunteering for the classroom and that the girls who frequently volunteered for high-level questions were the same girls who frequently volunteered for low-level questions. Conversely, the boys who frequently volunteered for high-level questions were not the same boys who frequently volunteered for low-level questions. Together these findings paint a very different picture of participation for each gender in first-grade mathematics classrooms.

Chapter 4

Discussion

Overall, we found that girls seemed eager to volunteer and participate in first-grade mathematics classrooms. In fact, they volunteered more than would be expected given the proportion of each gender in the classroom. This is also true when we looked at low-level questions: girls volunteered more than would be expected for low-level questions, given the proportion of each gender in the classroom, indicating their overall willingness to participate.

Given that others (e.g., Altermatt et al., 1998) found that boys volunteered more in middle-school science and mathematics classrooms, we had expected to find similar patterns in our data. We were thus surprised to find that in our sample of first-grade mathematics classes, girls participated more. This finding leads us to question why girls' volunteering drops off between first and fifth grade.

One potential explanation for the change in girls' participation in mathematics classes is that during these years children become both more self - and other-aware. This allows them to make comparisons about ability between themselves and their peers (Damon & Hart, 1982). These comparisons could impact the confidence of girls and inhibit their classroom participation. Fennema and Sherman (1977; 1978) found that boys in sixth- through twelfth-grade had greater confidence in their ability to learn mathematics than girls.

Although quite tentative, one of our sample teachers seemed to note a gender difference in confidence, thus providing some support for the hypothesis that confidence played a role in gendered student participation in first-grade mathematics classes. Teacher A said that she noticed that some girls in her class "know a lot about math too, but aren't as confident in themselves to [volunteer] quickly." This confidence difference between the genders likely arises from the cultural milieu and perhaps from particular classroom activities that position boys as better at mathematics than girls.

One such classroom activity that we noticed is volunteering for high-level questions. We found a small group of boys in each classroom who volunteered almost exclusively for high-level questions. It is likely that these boys would appear to the rest of the students in the classroom as smart or good at mathematics. Because boys appear to do better in the classroom, as indexed by their enthusiasm to take on the difficult mathematical questions, the confidence of the girls may decrease. This decrease in confidence is one of several reasons that may explain the different findings between the present study and other (e.g., Altermatt et al., 1998) investigations with older students. In particular, if girls lose confidence or see boys as more competent than they are in mathematics, we would see boys volunteering more than girls in the later grades, as Altermatt et al. reported, compared to what we found with first-grade boys and girls.

In fact, confidence may contribute to the later gender differences that we find in STEM careers. Roeser, Eccles, and Sameroff (2000) showed that a feeling of competence in learning is one factor of academic success in adolescents. Fennema and Sherman (1977; 1978) also found that for older boys, but not for girls, there was a significant correlation between confidence and performance in mathematics classrooms. Given the demonstrated importance of confidence, it is necessary to understand how girls and boys differ in their attributions of success.

Along these lines, Dickhauser and Meyer (2006) found that, although girls and boys did not differ in their general ability and grades, their attributions for success and failure differed. When compared to boys, girls attributed mathematics success to high effort, but attributed mathematics failure to low ability. Moreover, the girls' attributions were derived primarily from their perceptions of teacher evaluations of their ability. In contrast, boys relied on both perceived teacher evaluations and their objective mathematics performance. These findings indicated an interesting difference between the ways that girls and boys may develop confidence in the classroom. Girls tend to rely on the way they think the teacher feels about them, rather than on their own performance in the classroom. Also, girls tended to rate their perceived teacher evaluations as lower than boys. If girls feel that teachers do not think they are competent in mathematics, the girls' evaluations of their abilities will suffer and subsequently their confidence in the mathematics classroom will decrease.

When looking at students' assessments of their own ability, Carr, Steiner, Kyser, and Biddlecomb (2008) found that girls' assessments were more realistic of their actual ability, whereas boys over-assessed their ability. They also found that boys were more confident than girls, perhaps stemming from their over-assessments of their abilities. This confidence likely plays a large role in the career choices of students and may have its roots in early patterns of classroom participation.

Looking at the issue of the dampening of girls' participation over the course of their elementary school careers, we consider the teachers' intent when choosing which students they call on to answer questions. In particular, teachers often intentionally call on students who do not volunteer in order to get them involved in the classroom. In fact, two (C and D) of the three teachers (A, C, and D) in whose classrooms boys were not as eager to participate as girls may have called on the boys to encourage them to become engaged in the classroom activity. This idea is supported by the interview data from the teachers. All four teachers said they would try to call on students who were not volunteering so as to increase these students' participation in the classroom. Teacher C said, "I'll try to call on the kids that are not participating." Teacher B went a step further to state that, "Boys, at this level, get probably get called on more because of behavior issues. And there are boys that I need to call on more to keep engaged." She indicated that she calls on students who she feels need engagement to stay involved in the mathematics and that these students are typically boys.

This position is reminiscent of findings reported by Fennema and Peterson (1986). They found that teachers initiated non-volunteered and personal interactions more with boys than with girls. They indicated that the majority of these non-volunteered and personal interactions were initiated to keep the boys on-task. We also note, quite importantly, that Fennema and Peterson (1986) found that when directed to girls, these non-volunteered interactions were positively correlated with girls' high-level mathematics achievement. This tendency to seemingly favor boys could discourage girls from volunteering and decrease their confidence in the classroom because they observe that boys are being called on without volunteering.

This possibility of teachers favoring boys, which leads to discouraging girls' participation, is supported by recent work by Lang, Wong, and Fraser (2005). They found that the perception of student-teacher interactions is as important as the interactions themselves. More particularly, they found that the more positively the students rated the teacher's reaction, the higher the students' achievement. If being called on signals a positive teacher reaction, this would help explain why boys' achievement in mathematics eventually outpaces girls'. The findings of Lang et al. indicate that how girls and boys perceive teachers calling on boys is very important. If girls perceive that the boys are being favored or called on because they are more capable, this would impact their achievement.

Another possible reason for girls' decreased participation over the elementary school years is that early adolescent girls begin to focus heavily on their peer relationships. It is widely accepted that peers play a large role in the development of children (e.g., Ryan, 2001). Kurdek and Sinclair (2000) found that children's achievement in mathematics is correlated with the achievement of the other kids in their peer group (also see Ryan, 2001). Children are also more likely to choose peers who are similar to them in achievement. This causes a sort of feedback loop as children choose peers who are similar to them and then assimilate to those peers (Altermatt & Pomerantz, 2003; Kindermann, 1993; Crosnoe, Cavanagh, & Elder, 2003). This assimilation within peer groups allows for the perpetuation of attitudes and beliefs, including those about mathematics, such as the stereotype that mathematics is for boys.

Children tend to stereotype mathematics as a masculine subject. Steele (2003) found that girls were more likely to rate men as liking and being better at mathematics than women. In fact, in our ongoing work (Mingle, Schleppenbach, & Perry, 2009) we found that fifth-grade boys were four times as likely as girls to be nominated as one of the top three students in the class by their peers in spite of the reality that the top students (as measured by test scores) were almost evenly split between boys and girls. This indicates that the idea of mathematics as a masculine subject permeates the beliefs of young children and makes the assimilation of peers a dangerous way for these stereotypes to spread.

The repercussions of these early participation patterns and classroom activities extend far beyond elementary school. Children are socialized to participate in the classroom, and this socialization begins at least as soon as they enter formal schooling and perhaps even before. These learned behaviors will follow them through the education system and may shape their future career choices. Teachers should be aware of the ways in which they evoke classroom participation and understand that calling on particular students sends messages to each of the students in the class about who can answer that question—and why.

Future research should continue to look at the ways in which participation is socialized in elementary school, and perhaps even before students reach elementary school. There are many unanswered questions about how gender differences arise in higher education, and it is likely that some answers to these questions can be found early in students' education. Until we understand what causes these differences, we cannot really solve the problem, we can only treat the symptoms.

Footnotes

1. The students in Teacher A's and B's classrooms switched classrooms over the period of observation. In particular, some of the students who began in Teacher A's class moved to Teacher B's class in the winter and then returned to Teacher A's class in the spring. The remainder of students in Teacher A's class stayed in Teacher A's class in winter, then moved to Teacher B's class in spring. Teacher B's students followed the same pattern of switches.

References

Altermatt, E.R., Jovanovic, J., & Perry, M. (1998) Bias or Responsivity? Sex and achievement-level effects on teachers' classroom questioning practices. *Journal of Educational Psychology, 90 (3),* 516-527.

Altermatt, E. R., & Pomerantz, E. M. (2003). The development of competence-related and motivational beliefs: An investigation of similarity and influence among friends. *Journal of Educational Psychology, 95*, 111-123.

American Association of University Women (1995). *How schools shortchange girls*. Washington DC: Author.

American Association of University Women (2008). *Where the girls are: The facts about gender equity in education*. Washington DC.

Becker, J. R. (1981). Differential treatment of females and males in mathematics classes. *Journal for Research in Mathematics Education, 12*, 40-53.

Benbow, C. P., Lubinsky, D., Shea, D. L., & Eftekhari-Sanjani, H. (2000). Sex differences in mathematical reasoning ability: their status 20 years later. *Psychological Science, 11*, 474-480.

Brophy, J., & Good, T. (1974). Teacher-student relationships: Causes and consequences. New York: Holt, Rinehart & Winston.

Carr, M., Steiner, H. H., Kyser, B., & Biddlecomb, B. (2008). A comparison of predictors of early emerging gender differences in mathematics competency. *Learning and Individual Differences, 18*, 61-75.

Cherry, L. (1975). The preschool teacher-child dyad: Sex differences in verbal interaction. *Child Development, 46*, 532-535.

Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology (2000). "Land of Plenty". Retrieved December, 2008 from http://www.nsf.gov/pubs/2000/cawmset0409/cawmset_0409.pdf

Crosnoe, R., Cavanagh, S., & Elder, F. H. (2003). Adolescent friendships as academic resources: The intersection of friendship, race, and school disadvantage. *Sociological Perspectives, 46*, 331-352.

Damon, W. & Hart, D. (1982). The development of self understanding from infancy through adolescence. *Child Development, 53*, 841-864.

Dickhauser, O. & Meyer, W. U. (2006). Gender differences in young children's math ability attributions. *Psychology Science, 48 (1),* 3-16.

Fennema, E. & Peterson, E. L. (1986). Teacher-student interactions and sex-related differences in learning mathematics. *Teaching and Teacher Education, 2 (1),* 19-42.

Fennema, E., & Sherman, J. A. (1977). Sex-related differences in mathematics achievement, spatial visualization, and affective factors. *American Educational Research Journal, 14*, 51-71.

Fennema, E., & Sherman, J. A. (1978). Sex-related differences in mathematics achievement and related factors: A further study. *Journal for Research in Mathematics Education, 9,* 189-203.

Finn, J. D. (1993). School engagement and students at risk. National center for education statistics. Retrieved February, 2009 from http://gov/pubs93/93470a.pdf

Gallagher, A. M., De Lisi, R., Holstb, P. C., McGillicuddy-De Lisi, A. V., Morely, M., & Cahalane, C. (2000). Gender differences in advanced mathematical problem solving. *Journal of Experimental Child Psychology, 75* (3), 165-190.

Good, T. L., Sikes, J. N., & Brophy, J. E. (1973). Effects of teacher sex and student sex on classroom interaction. *Journal of Educational Psychology. 65 (1),* 74-87.

Gottfredson, L. (1997). Why g matters: The complexity of everyday life. *Intelligence, 24*, 79-132.

Irvine, J. J. (1986). Teacher-Student Interactions: Effects of Student Race, Sex, and Grade Level. *Journal of Educational Psychology, 78 (1)*, 14-21.

Kimball, M. M. (1989). A new perspective on women's math achievement. *Psychological Bulletin, 105,* 198-214.

Kindermann, T. A. (1993). Natural peer groups as contexts for individual development: The case of children's motivation in school. *Developmental Psychology, 29*, 970-977.

Kurdek, L. A. & Sinclair, R. J. (2000). Psychological, family, and peer predictors of academic outcomes in first- through fifth-grade children. *Journal of Educational Psychology, 92*, 449-457.

Lang, Q. C., Wong, A. F., & Fraser, B. J. (2005). Teacher-student interaction and gifted students' attitudes toward chemistry in laboratory classrooms in Singapore. *Journal of Classroom Interaction, 40 (1),* 18-28.

Leder, G. (1985). Sex-related differences in mathematics: An overview. *Educational Studies in Mathematics, 16* (3), 304-309.

Leder, G., C. (1992). Mathematics and gender: Changing perspectives. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 597-622). New York: Macmillan.

Leder, G. C. (1993). Teacher-student interactions, mathematics, and gender. In E. Fennema & G.C. Leder (Eds.), *Mathematics and gender* (pp. 149-168). Brisbane: University of Queensland Press.

Leinhardt, G., Seewald, A.M., & Engel, M. (1979). Learning what's taught: Sex differences in instruction. *Journal of Educational Psychology, 71* (4), 432-439.

Mingle, L.A., Schleppenbach, M., & Perry, M. (2009) Students' perceptions of top math students in the classroom. Manuscript in preparation.

National Science Foundation (2003). Women, minorities, and persons with disabilities in science and engineering: 2002. Retrieved December, 2008 from http://www.nsf.gov/statistics/nsf03312/pdfstart.htm

National Science Foundataion (2006). Survey of earned doctorates. Retrieved February, 2009 from http://www.nsf.gov/statistics/infbrief/nsf08308/

Roeser, R.W., Eccles, J.S., & Sameroff, A.J. (2000). School as a context of early adolescents' academic and social-emotional development: A summary of research findings. *Elementary School Journal, 100*, 443-471.

Ryan, A. M. (2001). The peer group as a context for the development of young adolescent motivation and achievement. *Child Development, 72,* 1135-1150.

Steele, J. (2003). Children's gender stereotypes about math: The role of stereotype stratification. *Journal of Applied Social Psychology, 33*, 2587-2606.

Stewart, A.J., Malley, J.E. & LaVaque-Manty, D. (Eds.). (2007). *Transforming science and engineering: Advancing academic women*. Ann Arbor, MI: University of Michigan Press.

Subotnik, R.F. & Strauss, S.M. (1995). Gender Differences in Classroom Participation and Achievement: An Experiment Involving Advanced Placement Calculus Classes. *Journal of Secondary Gifted Education, 6 (2),* 77-85.

Turner, J.C. & Patrick, H. (2004). Motivational Influences on Student Participation in Classroom Learning Activities. *Teachers College Record, 106 (9),* 1759-1785.

Willingham, W.W. & Cole, N.S. (1997). *Gender and fair assessment.* Mahwah, NJ: Erlbaum.

Appendix A

Tables

Table A1

Volunteering Relative to the Proportion of Male and Female Students in Each Classroom

Class	n	Observed boys' volunteering	Expected boys' volunteering	Observed girls' volunteering	Expected girls' volunteering	χ^2
A	188	69	80.84	119	107.16	3.042
B	491	260	240.59	231	250.41	3.070
C	882	332	396.9	560	485.1	25.699*
D	492	222	246	270	246	4.728*
Total	2053	873	964.33	1180	1088.67	16.312*

*$p < 0.05$

Table A2

Teacher Responsiveness Relative to the Proportion of Male and Female Students in Each Classroom

Class	n	Observed number of times a boy is called on	Expected number of times a boy is called on	Observed number of times a girl is called on	Expected number of times a girl is called on	χ^2
A (1)	72	26	30.79	46	41.21	1.302
B (1)	121	58	59.42	63	61.58	0.424
C (1)	182	76	81.28	106	100.72	0.620
D (1)	74	38	37.37	36	36.63	0.021

Table A3

Teacher Responsiveness Relative to Student Volunteering in Each Classroom

Class	n	Observed number of times a boy is called on	Expected number of times a boy is called on	Observed number of times a girl is called on	Expected number of times a girl is called on	χ^2
A (2)	72	26	27.39	46	44.61	0.114
B (2)	121	58	56.01	63	64.99	1.624
C (2)	182	76	67.41	106	114.59	1.739
D (2)	74	38	32.85	36	41.15	1.452

Table A4

Volunteering on High-and low-Level Questions Relative to the Proportion of Male and Female Students in Each Classroom

Class	n	Observed boys' volunteering	Expected boys' volunteering	Observed girls' volunteering	Expected girls' volunteering	χ^2
A (high)	43	14	18.49	29	24.51	1.913
A (low)	145	55	62.35	90	82.65	1.520
B (high)	45	26	22.05	19	22.95	1.387
B (low)	446	234	218.54	212	227.46	2.144
C (high)	118	49	53.1	69	64.9	0.576
C (low)	764	273	343.8	491	420.2	26.509*
D (high)	40	20	20	20	20	0.000
D (low)	452	202	226	250	226	5.155*
Total (low)	1807	764	850.69	1043	956.31	16.693*

*$p < 0.05$

Table A5

Teacher Responsiveness to High- and low-Level Questions Relative to the Proportion of Male and Female Students in Each Classroom

Class	n	Observed number of times a boy is called on	Expected number of times a boy is called on	Observed number of times a girl is called on	Expected number of times a girl is called on	χ^2
A (high)	20	7	8.6	13	11.4	0.522
A (low)	52	19	22.36	33	29.64	0.886
B (high)	14	8	6.86	6	7.14	0.371
B (low)	107	50	52.43	57	54.57	0.221
C (high)	21	7	9.45	14	11.55	1.155
C (low)	161	69	72.45	92	88.55	0.299
D (high)	11	6	5.5	5	5.5	0.091
D (low)	63	32	31.5	31	31.5	0.016

Table A6

Teacher Responsiveness to High- and low-Level Questions Relative to Student Volunteering in Each Classroom

Class	n	Observed number of times a boy is called on	Expected number of times a boy is called on	Observed number of times a girl is called on	Expected number of times a girl is called on	χ^2
A (high)	20	7	6.6	13	13.4	0.047
A (low)	52	19	19.76	33	32.24	0.036
B (high)	14	8	8.12	6	5.88	0.004
B (low)	107	50	55.64	57	51.36	1.191
C (high)	21	7	8.82	14	12.18	0.648
C (low)	161	69	57.96	92	103.04	3.286
D (high)	11	6	5.5	5	5.5	0.091
D (low)	63	32	28.35	31	34.65	0.854

Table A7

Percentage of Volunteering Done by the top Quarter of Volunteerers of Each Gender for High- and low-Level Questions and Correlations Between Volunteering for High- and low-Level Questions.

Class	Percent of volunteering for high-level questions	Percent of volunteering for low-level questions	*r*
A & B girls	42.9% (4)	54.8% (6)	.580*
A & B boys	63.3% (4)	54.7% (7)	.057
C girls	51.7% (4)	49.9% (4)	.739*
C boys	44.7% (3)	42.5% (3)	.343
D girls	60.0% (3)	53.0% (4)	.500
D boys	47.6% (3)	41.0% (3)	.291

*$p < 0.05$