Mathematics Stories:
Preservice Teachers' Images and Experiences as Learners of Mathematics

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Objective

Decades of research have demonstrated that American mathematics instruction can be characterized by certain distinctive practices (Cuban, 1993; Wilson, 2003) and that teachers' beliefs and classroom practices are shaped by their constructed experiences in school and beyond (Ball, Lubienski, & Mewborn, 2001; Clark & Peterson, 1986). Guided by the goal of intervening productively in preservice teachers' mathematics histories to shape future classroom practice, this study sought to address the questions: What are prospective teachers' pre-credential program experiences with mathematics? How do these experiences contribute to teachers' images of themselves as teachers and to their notions of what it means to teach well?

Theoretical and Empirical Framework

The United States faces general concern over mathematics proficiency. The encouraging news is that, by more than one measure, test scores are on the rise. International comparisons through the Trends in International Mathematics and Science Study (National Center for

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Education Statistics [NCES], 2009a) show that U.S. eighth graders have risen to a rank of nine out of the participating 48 countries, up from the middle in the 2004 study (NCES, 2004). Additionally, fourth and eighth graders' mathematics scores on the National Assessment of Education Progress have never been higher (NCES, 2009b). Despite this encouraging news, the nation's progress is neither swift nor equally shared by subgroups of our diverse student population. For instance, only one-third of the nation's eighth graders scored as "proficient" or "above proficient" on the most recent survey of educational progress (NCES, 2009b). Additionally, students who are learning English; who qualify for a free or reduced lunch; whose parents have lower levels of education; who have disabilities; or who are classified as Black, Hispanic, or American Indian all experience lower mean scores in mathematics.

As a result of continued concerns over mathematical literacy, the nation has invested in large-scale reform efforts of mathematics education. Mathematics reforms across the nation (National Council of Teachers of Mathematics, 2000) have focused on re-examining the "technical model of teaching" (McDuffie, 2004). These reforms have attempted to create reflective practices and have worked to allow students to conceptualize the mathematics content better.

Results of these and other reform efforts appear to be mixed. Studies based on teachers' self-reports of their practice suggest some changes in teaching and learning. For instance, the Rand Corporation (2000) Mosaic study found that teachers reported increasing use of reform-based practices in the mathematics classrooms. Teachers in the Seventh National Assessment of Educational Practice (NAEP) reported engaging more frequently in practices that were consistent with reform efforts than did teachers in the previous NAEP study (Silver & Kenney, 2000). More recently, MacIver and MacIver (2009) found higher levels of student mathematics performance in schools engaged in longer periods of mathematics reform.

Much evidence (reviewed by Wood, Shin, & Doan, 2006), however, suggests that we have yet to see deep or widespread change in mathematics classrooms. Wilson (2003) concluded that the U.S. seems to share a common experience in mathematics based on a national script for teaching mathematics. "Class begins with a homework review, followed by a teacher demonstration of the algorithm-of-the-day. Ample time is usually left for practicing problems, and an audible collective sigh of relief is heard whenever word problems are not assigned" (p. 4).

Many factors appear to account for our struggles to improve mathematics education and achieve mathematical literacy. One appears to be our collective conception of the nature of mathematics. Some academic areas such as social studies and language arts are seen as subjects that one interacts with daily outside of school (Grant, 1996). These subjects may be perceived as obscure but attainable, and they are described using a wide array of definitions and viewpoints. In contrast, mathematics is seen as fixed with procedures and rules that begin when school begins (Kloosterman, Raymond, & Emenaker, 1996). Students of many ages view mathematics as restricted to numbers and related operations (Kloosterman et al.; Sylvester, 1980). As early as preschool, teachers focus on language related to numbers to the exclusion of other mathematics strands. For example, Rudd, Lambert, Satterwhite, and Zaier (2008) argue that over 70% of the math-mediated language focuses on lower-level thinking skills such as "number" as opposed to language such as operations, patterns, or geometry. Similarly, teachers define mathematics in terms of algorithms and computational proficiency (Wilkins, 2000). Almost certainly, changing such deep-seated and limited collective notions of the nature of mathematics will take massive efforts and extended periods of time.

Although some evidence suggests that change in our conceptions of mathematics, and in our efforts to improve mathematical literacy, will be slow, one fact is certain: teachers make a difference in student learning. Wenglinsky (2001) found that teacher behaviors have a larger influence on student mathematics achievement than does the potent predictor socioeconomic status. Other researchers also have found that factors such as teacher certification and teacher experience affect student mathematics achievement (e.g., Darling-Hammond, 2000; Nye & Konstantopoulos, 2003). Given the incredible power that teachers hold to make a difference in students' mathematical development, a reasonable point of entry for improving student learning is to work carefully with teachers to ensure that they have the knowledge, skills, abilities, and opportunities to maximally affect student learning in mathematics.

At least two factors affect mathematics instruction and instructors: (a) teachers' previous experience and beliefs and (b) teachers' subject matter knowledge (Gabriele & Joran, 1998; Grant, 1996; Johnston & Whitenack, 1992; Riedesel & Schwartz, 1994). First, teachers' previous experiences and beliefs powerfully affect how they teach mathematics (DeCorte, 1996; Ferguson, 2008). Teachers' past negative experiences as students can impede the uses of mathematics in the classroom (Gabriele & Joran, 1998; Grant, 1996; Johnston & Whitenack, 1992; Riedesel & Schwartz, 1994). Additionally, there is a general belief that some people have an innate ability to understand mathematics whereas others do not (Grant). Teachers with this belief may shun advanced study, limit their teaching of the subject, and unwittingly teach their students that it is acceptable to avoid math if they do not have innate ability to understand it. In short, it would be difficult to expect our teachers to be role models for U.S. students to experience the beauty, power, and richness of mathematics if they themselves have been granted limited opportunities to experience mathematics in this way.

Second, teachers' knowledge base affects mathematics instruction. Researchers and policymakers often conclude that increasing teachers' subject matter knowledge will enhance student learning (Hill, Rowan, & Ball, 2005; Kahan, Cooper, & Bethea, 2003), a major premise behind the *No Child Left Behind* Act's (2001) emphasis on highly qualified teachers. For instance, teacher avoidance and anxiety in the area of mathematics have been directly linked to "inadequate preparation in mastery of fundamental skills" (Wittman, Marcinkiewicz, & Hamodey-Douglas, 1998, p. 9). Underprepared teachers are unlikely to teach with the needed confidence and skills to foster deep mathematics learning, and one result may be underprepared students.

In sum, U.S. teachers are products of the school systems that they pass through as students and reenter as professionals. These years of experiences with mathematics in school (and out) influence the convictions, beliefs, and values that teachers bring with them to their professional preparation programs and to the classroom. Despite these previous experiences, teacher education also has an impact on professional preparation. Unfortunately, teacher educators most often have very limited time to work with prospective teachers. As a result, teacher educators must make very careful decisions about providing learning opportunities that are likely to have great influence on future practice.

This study seeks to determine whether national trends in subject matter knowledge and in curricular experiences hold true for prospective teachers who attended K-12 schooling during the reform period. It further seeks to determine other influences on teachers' visions of mathematics and goals for themselves as mathematics teachers. As noted above, teachers' past experiences and knowledge have an impact on their ability to teach mathematics. Autobiographies, or what we are calling math stories, provide one way to study these experiences (Ellsworth & Buss, 2000; Millsaps, 2000). Through the powerful lens of mathematics stories, this study seeks to view teachers' past experiences, to begin to deconstruct possible limiting notions, and to build on solid notions of mathematics and mathematics instruction to better shape classroom practice for tomorrow's students.

Methods

To explore teachers' mathematics stories, we conducted an interpretive study with 144 preservice elementary teachers enrolled in a two- or three-semester postbaccalaureate teacher preparation program.

Participants

Participants were enrolled in a mathematics methods course, seeking initial certification in elementary education (via multiple subject credentials) at a large, cohort-based, public institution in the Southwest. Given state requirements, each participant had previously completed an academic major (not education) and was required to prove "subject matter competence" in mathematics and other subjects, either through coursework or through a national examination. They also each passed a state test of basic skills in English and mathematics.

The 144 participants, representing five different cohorts, mirrored the nation's demographic trends for teachers in that the majority were female, White, English speakers who were entering teaching as a first career (U.S. Census Bureau, 2000). However, 20% (n=30) of the participants were Hispanic, seeking bilingual certification in Spanish, and a small proportion (6%; n=9) of the participants were fluent in Korean or Vietnamese in addition to English and were pursuing bilingual credentials in an Asian language. Many participants from these bilingual credential groups, and some participants from the larger sample as well, were born outside the U.S. Some attended school elsewhere before attending school in the U.S., and some acquired English upon entering the U.S. school system. Ethnic groups represented in smaller numbers (each constituting less than 2% of the sample) included African Americans, Indians, and Philipinos. Additionally, 13% of the sample were male.

Approximately two-thirds of the participants were "traditional" credential students in that they passed directly through elementary and secondary school, through college, and into teacher education. As such, they would have attended elementary school during the late 1980s, secondary school during the 1990s, and graduated from college in 2001. Most participants, then, attended school at the time that many mathematics reform efforts should have been taking hold in the nation's classrooms.

Data Sources

Participants supplied two sources of data for analysis. Before formal mathematics methods instruction began, they submitted electronically their personal histories with mathematics. They were to consider, as far back in time as they could remember, both in-school and out-of-school experiences, including people and experiences that had a strong effect (either positive or negative) on them in mathematics. They were not given limitation on length, and this assignment (see Appendix) was a requirement for the mathematics methods course. In addition, as an in-class activity, participants analyzed their personal histories, focusing on both attitude and achievement, and charted those analyses as line graphs (see Figure 1). Finally, class discussions served as a data source and an opportunity for participants to contribute to the data analysis.

Analyses

Data were analyzed through standard content analytic procedures (e.g., Bogdan & Biklen, 1992; Miles & Huberman, 1994; Strauss & Corbin, 1990). As advocated by Patton (1990), we used multiple sources of data—math stories, line graphs, and class discussions—to help establish trustworthiness.

We analyzed line graph data in a number of ways. First, we measured the endpoints (self-ratings of performance and attitude at entry to the credential program) of the graphs for each participant. We used descriptive statistics and forced categories (low, medium, and high) to portray general trends in participants' self ratings. Second, we ran a Pearson product-moment correlation (r) to compare attitude and performance self-ratings across participants. Third, we classified the shape of each curve. We similarly analyzed math story data in a number of ways. First, we independently analyzed personal histories for themes, using frequency counts to check for prevalence of the themes. We then shared findings with participants in our own cohorts. Participants responded through class discussion to the tentative themes, at times verifying them and at times suggesting refinements. Next, we shared the datasets with each other to check the accuracy of coding and to establish internal validity through triangulation (Denzin, 1978). We collapsed frequency counts across cohorts and modified themes to account for the experiences of participants across the entire sample. Care was taken to consider alternative explanations of the data that were used to refine our analysis of major themes.

Results and Discussion

The analysis of 144 preservice elementary teachers' mathematics stories (told via math story essays and line graph representations) yielded six categories of findings: (a) attitude and performance outcomes, (b) peaks and valleys, (c) math stories as school stories, (d) memories of school mathematics, (e) the power of the teacher, and (f) beliefs about good practice.

Self-Reported Attitude and Performance Outcomes

As was the case in the Ellsworth and Buss (2000) study, these participants' mathematics stories were primarily positive. Upon entry into the credential program, most participants felt at least moderately successful with math, both in terms of attitude and performance. On a 0-5 (6-point) scale, line graphs show that participants rated their performance (x= 3.4; SD = 1.3) and attitude (x= 3.1; SD = 1.1) as high. For example:

> I have always liked math in school and out of school. I have found mathematics challenging at times, but that is what made it interesting to me. I like figuring out things that seem difficult or cause you to have to think about them.

The correlation between participants' attitude and performance was r = .82, and this typically close relationship between attitude and performance is clear upon visual inspection of participants' line graphs, where the lines for performance and attitude usually tracked each other closely.

Although most participants expressed positive attitudes toward mathematics and expressed high self-ratings of success, experiences did range across the group. The frequency of participants reporting low (or negative), neutral (or mid), and high (or positive) attitude and performance in mathematics is represented in Table 1.

Although relatively few participants gave low performance (13%) and negative attitude (19%) self-ratings, those who did so were often emphatic. One student's experience serves as an example:

> I can only think of one word to sum up my experiences with and feelings about mathematics—YUK! From elementary school to college I have had a deep dislike for math. My stomach turns, the room suddenly gets hotter and I feel as if I would rather be in the process of getting a root canal than spending an hour trying to calculate the exact time two trains will collide if they are heading toward one another at different speeds.

Nevertheless, Table 1 demonstrates that 80% of the participants reported neutral to very positive attitudes, and 85% reported middle to very high success in mathematics performance. In contrast to perceptions

Table 1
Categories of Self-Reported Attitude and Performance in Mathematics

Self-Report	Very Low to Low (Negative) (0-2.0)	Neutral (Mid) (2.1-3.0)	High to Very High (3.1-5.0)
Attitude	27 (19%)	33 (23%)	82 (57%)
Performance	19 (13%)	35 (24%)	88 (61%)

Note. N=144.

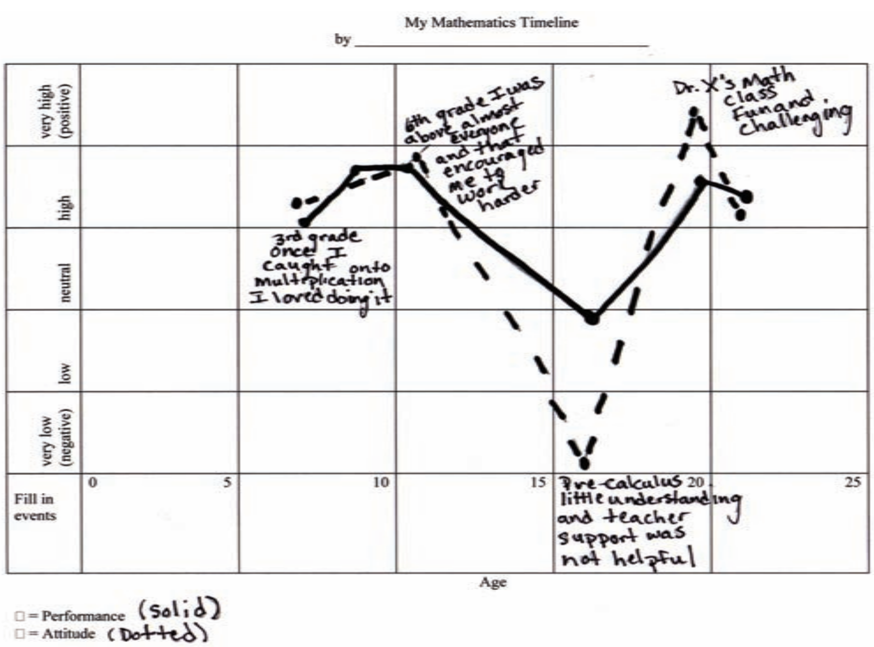
of math phobia held by some in the public at large, most participants were comfortable with their knowledge of mathematics, were committed to learning more mathematics throughout their careers, and were eager to teach children. An example speaks for the majority of participants:

> Overall my extremely positive experience in math and the confidence I built from an early age gave me the love for math that I have today. I have seen the significance of building confidence and provoking interest in math by the experiences of my own life and hope to be able to encourage my students in both of these areas. The many wonderful math teachers I have experienced provided me with insight into lesson ideas and teaching strategies.

Peaks and Valleys

Although the stories revealed that most participants felt at least fairly knowledgeable and expressed eagerness to teach mathematics well, their stories were not were not uniformly upbeat. Most stories included both experiences perceived as powerfully positive and as poignantly negative. A clear majority (81%) of the curves drawn to represent participants' personal mathematics history timelines included peaks and valleys (Figure 1). This is in contrast to the trend-like nature of the line

Figure 1



graphs that participants tended to create in their reading methods course for their histories as readers. Participants noted events and memories that they characterized as happy or positive and sad or painful during their mathematics histories. Many participants used analogies such as roller coasters and windy or bumpy roads to describe the up-and-down nature of their histories.

As described in a later section, peaks and valleys were often precipitated by participants' reactions to particularly powerful teachers, by their reaction to content (e.g., geometry or algebra), or by significant experiences such as course examinations or particular phases in their own social or emotional development. The combination of the positive and negative experiences of the vast majority of participants contributed to their overall view of mathematics and how it should be taught. Some participants were fueled by their desire to do better than their teachers had done for them. One example may suffice:

> I know what it feels like to be discouraged by a teacher and what it feels like to have a teacher tell you that you are not good enough or that you can't pass a math class. It is my desire to not bring a negative feel to the classroom environment for math . . . I know that when I discovered how many ways that I use math in my life it became easier to me. I hope that no student has to go through what I went through to develop a desire to learn math.

Math Stories as School Stories

Participants' mathematics stories were primarily stories of school. Although some participants shared home experiences in their stories, home influence was frequently limited to preschool experiences, often with numbers. Many participants, for instance, recalled their mothers teaching them to count objects or their fathers helping them to count change. Family activities such as cooking and sports provided an early mathematical context for a small number of participants. For example, DN recalled:

> I can still remember my uncles asking me [at the age of five] who was winning and by how much during the 1985 NBA finals between the Los Angeles Lakers and the Boston Celtics. I can still remember vividly Magic Johnson's infamous hook shot at the top of the key to beat the Celtics at the Garden. Ironically this was how I learned to add and subtract.

Home influence faded through the elementary years so that, by secondary school, when a story mentioned home influence, it was in the form of family members assisting with homework. It appears that families' support of school mathematics throughout the schooling years became more dependent upon family members' formal education in mathematics. Those participants with family members who were teachers or professionals who used mathematics appeared to have more family involvement than did their peers. Not all participants, however, viewed family influence as "support." Some included stories of fights with parents stemming from mathematics, and some told of the pressure that they experienced as their families grew concerned about their school performance.

Of our 144 participants, only 60 (42%) spontaneously discussed some type of home connection to mathematics. Of these 60 participants, just over half (n = 32; 53%) gave accounts that were still school-related activities completed at home. Thus, the majority of the home connections to mathematics stemmed from school work or school activities. Examples include homework support, tutoring, worksheets, and flashcards for drill, as illustrated in Table 2.

In short, fewer than half of the participants who mentioned a home connection to mathematics reported non-school-based math experiences out of school. Most (116 of 144; 80.5%) participants reported either no family experiences with mathematics or solely school-related experiences with mathematics at home.

Memories of School Mathematics

Given the prominence of school mathematics in participants' mathematics autobiographies, it is important to examine the outcomes and practices experienced by participants throughout their histories. An important caveat is that memory is fallible and that participants' memories of teachers' intended outcomes and practices may be affected by at least two powerful factors. First, participants may have been unaware of their teachers' intended outcomes and strategies. Second, they may have elected not to write about outcomes and practices to focus on features that were more salient in their own perceptions. As one participant noted:

> I do not remember much of anything about the math instruction I received at school until the seventh grade. I cannot say with certainty

Table 2
Participants' Memories of Out-of-School Connections to Mathematics

Workbooks/ Flashcards	Tutoring/Help with Homework	Memories of Out-of-School Connections to Mathematics	Work	"Sesame Street"
24 (40%)	15 (25%)	10 (17%)	7 (12%)	4 (6%)

Note. Percentages are based on the number of participants who discussed memories of mathematics outside of school (n = 60).

> that this is a sign of the quality of the math instruction I was exposed to. However, it does appear that my math instruction from grades three to six were unmemorable. Perhaps it is unfair to say that the teachers were bad. After all, my knowledge of math is adequate enough. It appears my elementary teachers were in fact teaching me to add, subtract, multiply, divide, estimate, measure, etc. I apparently did learn the basics somewhere along the way, just not in a way that I can remember.

Despite the fallibility of memory, some interesting trends arose in participants' memories of school events. These include intended outcomes of schooling, prevalent practices, the power of the teacher, and beliefs about good practices.

Intended outcomes. Nearly two-thirds of the stories (*n*=91; 63%) gave information about participants' memories of the outcomes pursued in classrooms, from kindergarten to college. Table 3 categorizes participants' unprompted memories of outcomes including procedural competence, conceptual understanding, and problem solving.

This table reveals some themes. First, *procedural recall* (largely *memorization*) is the most-often reported memory of outcomes in elementary school. For example, one student described her experience with the most frequently cited elementary school memory, memorization of multiplication facts:

> My first clear recollection of math instruction is my 4th grade nemesis, the Four-Minute Club. I could not for the life of me get myself into that darn Four-Minute Club by doing 200 multiplication problems in four minutes. I was always the smartest girl in the class, and suddenly I had failed. This was humiliating, and as hard as I tried, I failed the next time, too. My parents tried to help me with flashcards, but my poor bruised ego had had enough of stupid multiplication. I felt dumb,

Table 3
Participants' Memories of Various Outcomes of School Mathematics

Outcomes	Elementary School	Junior High School	High School	College
Procedural (including memorization)	68 (84%)	4 (4%)	13 (14%)	8 (9%)
Conceptual Understanding	21 (23%)	4 (4%)	10 (11%)	12 (13%)
Problem Solving	13 (14%)	5 (6%)	4 (4%)	2 (2%)

Note. Percentages are out of 91, the subset of participants who recalled outcomes. Essays often included more than one type of outcome.

> and I knew I wasn't dumb, and I hated that feeling. I think it took me four tries to pass. Enough other kids had passed before me that I didn't even *want* to see my name up on that horrible yellow bulletin board when I finally conquered it. There was absolutely no joy in that victory. I still hate ticking timers.

Although reports of procedural proficiency declined as explicitly mentioned outcomes after the elementary years, the table indicates that procedural competence is not clearly replaced by other outcomes as student progress through the years. Our hypothesis is that procedural outcomes remained prevalent, just less memorable to the participants as they became accustomed to "standard practice" of mathematics instruction. This hypothesis is supported by participants' discussion of traditional book work, homework, and examinations.

Second, clear mentions of *conceptual understanding* were more numerous in elementary school than in other grades, and a small resurgence of reporting of conceptual outcomes occurs in college. In elementary years, participants remembered focusing on conceptual outcomes such as the meaning of counting, of operations, and of time and money. Many of the 12 mentions of conceptual understanding in college were related to courses for elementary teachers that focused on conceptual structures that children should learn. For instance, one student stated:

> The concepts in these elementary math [courses] were entirely new to me. We had to take an entirely different approach to how math worked. It was like we turned it inside out to see how we actually came up with different formulas and had to look at why answers were what they were. Those were two of the best semesters that I had in math.

Third, *problem solving* as an outcome was reported with low frequencies at all levels. No more than 13 instances of problem solving were mentioned at any one level. At the elementary level, a few participants mentioned word problems, brain teasers, estimation, or problem solving strategies. Only one student provided a vignette that can be seen as striking the heart of the solving of nonroutine problems as an outcome of the elementary grades:

> From elementary school all I can recall is that in fifth grade we worked continuously on problem solving. Something memorable to me is when Ms. M asked, "There are three people. They each weigh 60 pounds. They all need to cross a river, but there is only one boat and it can only hold 120 pounds. How do they manage to get across?"

The fact that memory is imperfect is especially important for teacher educators working with prospective teachers. Although preservice teachers may have experienced a balanced and rich curriculum that focused on not just one but three critical outcomes in mathematics, participants did not have memories of such balance. Instead, their memories included a heavy focus on procedural competence and little attention to problem solving. The research on teacher cognition from the past few decades (e.g., Ball et al., 2001; Clark & Peterson, 1986) illustrates just how firmly teachers' classroom practices are based on their own constructed experiences from formal (and informal) educational experiences. Even when given reform-minded curricular materials, teachers in some studies used the materials in ways shaped by their constructed "traditional" understandings of mathematics. Thus, the finding that teachers remember most clearly procedural outcomes may translate into classroom practices that focus on the "correct" or "normal" outcomes of mathematics.

Prevalent practices. Through which practices did participants work toward mathematics outcomes? Of the total sample (*N*=144), a subset of 86 participants recalled tasks and practices. Participants often included more than one type of practice in their essays, so totals exceed 100%. Percentages are of the subset of 86 participants recalling practices.

The following list underscores several notable trends:

1. *Textbooks and worksheets* were mentioned frequently (65%) in the elementary grades, and were recalled less frequently in the higher grades. It appears that teachers in the higher grades and in college continued to use such materials but that participants wrote less explicitly about them.

2. *Direct instruction*, including components such as lecturing, explaining, working sample problems, and checking students' problems, was mentioned consistently (59%). Participants assigned a range of evaluations (positive and negative) to direct instruction practices, especially at the high school level.

3. *Manipulatives* were mentioned (31%) during elementary school and college, which parallels the trend of memories of a conceptual focus. Fully half of the mentions of manipulatives occurred in college, in the content area course for prospective teachers. The frequency of mentions of manipulatives is lower than one might expect, given reform efforts aimed at enhancing conceptual understanding.

4. *Competition* was often mentioned in elementary grades (typically associated with memorization tasks) and dissipated as a classroom teaching strategy in the later grades (14%).

5. *Real-life connections* were mentioned infrequently but always in a positive way (17%).

6. *Low incidence* strategies, tasks, and practices included strategies such as the use of technology, writing in mathematics, projects, field trips, and discussion (17%). Some of these low-incidence strategies might be considered as consistent with reform efforts to broaden students' experiences with mathematics.

The school tasks, practices, and materials recalled by participants reflect those found in other research. These memories are consistent with many of the findings of the Trends in International Mathematics and Science (TIMSS) study (NCES, 2003). Participants in the current study told of algorithm-based instruction focused largely on drill and memorization. For instance, one student stated, "Most of my mathematical education in elementary school consisted of traditional bookwork, dittos, and tests. I do not remember many hands-on experiences."

As a caveat, it appears that the measure (open-ended self report) was noticeably imperfect in that it did not systematically probe participants' recalled experiences related to particular tasks and practices. Nonetheless, general patterns and trends are visible in participants' memories, and these are consistent with trends found in classrooms up and down the grades and across the nation. As a result, it may indeed be that case that, "Most adults graduate from school never having experienced any of the power, elegance, and beauty of the subject [mathematics]" (Ball et al., 2001, p. 435).

One other interesting conclusion about school mathematics can be drawn from the findings of the current study. The "hidden" curriculum was a powerful outcome of school mathematics for a subset of the sample. Although not every story discussed the implications of the hidden curriculum, those participants who included it in their essays were deeply affected by the "caught" (as opposed to the "taught") curriculum. Longstreet and Shane (1993) refer to the hidden curriculum as "the kinds of learning children derive from the very nature and organizational design of the public school, as well as from the behaviors and attitudes of teachers and administrators" (p. 46).

Thus, whether intended or unintended, whether positive or negative through structures and practices of schooling, participants "learned" messages about their own intelligence and ability (or lack thereof) to do mathematics based on individual factors, based on their race, based on their gender, and based on their ethnicity. Individuals "learned" that they were smart (or not). Asian men and women chafed against the stereotypes that all Asians excel in mathematics, white women chafed against lowered expectations based on their gender, and Mexican American women chafed against lowered expectations that accompanied their ethnicity and gender. One student's story, for example, speaks clearly of the lessons of gender and ethnicity that can be learned:

> Then fourth grade happened to me. I was in Mr. M's class. Not only was he a man, but a brown one (not blond or red haired like my uncles [but brown like me]), and he, he was in a position of being in charge, not the janitor . . . One day the teacher kept me after school and he told me that he knew that I could add, subtract, multiply and divide very quickly in my head and he wanted to know how I did it. So I shared my secret method for quick addition . . . I asked Mr. M. to promise not to tell anyone because I wasn't supposed to know things because I was brown and a girl. He laughed and laughed and pretty soon we were both laughing hard. He said, "Some very stupid people made you believe this. It isn't true. It's a joke on them." With this teacher's encouragement I went from fourth grade to sixth, skipping fifth grade, never giving it a thought until now.

The power of the teacher. Mathematics stories were clearly stories about the power of teachers. The peaks and valleys on participants' graphs and in their essays gave memorable accounts of individual teachers who served, for better and worse, to shape participants' successes and failures with mathematics. Of our 144 participants, 98 (68%) discussed the power that at least one teacher had on their outlook on math and their self-esteem. Of the 98 participants who discussed the power of the teacher, 73 (75%) argued that one teacher changed their view of mathematics in ways that had long-lasting effects on their views of mathematics.

Stories shared the effects of both positively and negatively powerful teachers across all levels of schooling. Two notable positive examples include:

> She was my teacher for a whole year and I liked her very much; I firmly believe that because of her . . . I learned to like math.

> The impact of my Math 200B teacher will stay with me forever . . . For the first time in my life I truly enjoyed attending math class and even received an A. This was a major turning point for me.

Some teachers had similarly powerful, albeit negative, effects on participants. These stories include:

> I remember in second grade my teacher would yell at us students when we did not understand math . . . I think it was from this point on I dreaded math.

> Then Mr. L., my senior year mathematics teacher happened to me. He made it loud and clear that he believed I couldn't handle his class . . . I have never recovered from this experience, and it affects me today.

Both male and female participants reported the positive and negative power of teachers, and potent memories included teachers as early as first grade and as late as college. In most cases, powerful teachers' influences reached not only across the year in which they taught our participants but into future years as well. However, powerful teachers' effects were often mitigated by future teachers. The good done by one positive teacher might be undone by one perceived as poor and vice versa. The "peak-and-valley" nature of participants' graphs indicates that participants' attitude (and performance) self-ratings were plastic and subject to future modification, often by teachers (see Figure 1).

Perceptions of mathematics as a school-based subject may be related to the powerful roles that teachers can play in students' histories. Participants tended to experience mathematics, unlike reading, primarily in school. As one student stated, "[Mathematics] wasn't like reading; I didn't do pleasure math at home like I did pleasure reading." It seems likely that, because out-of-school experiences are limited in mathematics, teachers may play an especially potent role in shaping students' attitudes toward the discipline and toward themselves.

Beliefs about good practice. Finally, participants' stories paint portraits of classroom practice that they viewed as poor or positive. The chapters of their math stories composed prior to the credential program resulted in some fairly well developed notions of what it means to teach well. Six themes can be found in participants' stories:

> *Good teachers believe in their students and convey that conviction.* As some of the quotes presented in "The Power of the Teacher" section indicate, participants had vivid memories of teachers who called them stupid or who paid no attention to them because they did not believe they could learn. Participants also told powerful stories of teachers whose faith in their students never wavered and who were able to convince their students of their abilities and take them on to succeed in mathematics. As one student stated, she learned over the years that, "Math is only as hard as your teacher makes it." Good teachers, in participants' views, believe in their students.
>
> *Good teachers' instructional decisions are driven by the goal of student learning.* Participants shared stories of teachers who

ignored students' questions, needs, and progress to instead base decisions on other factors. For example:

> When I was in a geometry class, I found that I was totally lost. I could not understand several of the concepts nor was I able to "see" the abstract shapes and figures. My teachers were not very helpful and only taught using one method, lecture. They did not adjust their teaching strategies to the needs of their students. Many of the students in my class were confused right along with me. The instructors did not use any hands-on activities or manipulatives so that visual learners could "see" the figures.

Participants also shared instances of teachers who served as their role models by basing their instructional decisions solidly on students' learning. Some teachers would not "go on" until every student understood. Some would spend their own time before and after school, during lunch, or on weekends in order to help students understand. Some would use multiple methods to explain concepts when the first method was ineffective. Some would advocate for their students within the school setting. Each of the actions that teachers took helped cement participants' commitment to placing students and their understanding at the center of their instructional decisions.

Good teachers teach for conceptual understanding. Data presented earlier indicate that most participants recalled experiencing a mathematics curriculum that focused on procedural competence. Many felt frustrated by the dearth of answers they received from their teachers to the question, "Why?" Some participants experienced the high point of their mathematical understanding when, finally, in college, they learned the conceptual underpinnings of the elementary curriculum. Participants cited strategies such as pictures, concrete materials, clear explanations, effective use of direct instruction, and multiple means of explanations as supportive of their goals of conceptual understanding.

Good teachers use methods that are interesting and engaging to students. Participants appreciated strategies that moved beyond text and workbook activities to include activities such as songs and chants, games, simulations, and projects. They appreciated teachers who sparked a love for the subject matter by capitalizing on students' outside interests and students' preferences for enjoyable, engaging activities. Although participants equally praised some strategies, others (namely, speed competitions for multiplication drill) were met with highly mixed reviews. The points seems to be that good teachers listen to their students and select teaching strategies that respond to students' particular preferences and needs for interesting activities.

Good teachers create settings where students feel safe to take risks. Participants shared stories of teachers in whose classrooms they felt nervous and worried about making errors. They developed strategies to avoid invoking the eye of the teacher. Public humiliation, often during recitations of math facts or doing problems on the board, figured prominently into participants' views of unsafe learning environments. Conversely, they told stories about teachers who created classrooms where, "There were no stupid questions," where students felt motivated to try, and where intellectual progress was fueled by teachers' attention to students' attitudes toward mathematics as well as their performance.

Good teachers show the connections between mathematics and other facets of life. Data presented earlier suggest that few participants recalled teachers placing mathematics in a real life context. Just 15 of the 144 (10%) told of instances of real-life connections in school. In fact, participants' inability to contextualize mathematics into their lives served as a source of frustration for many. one student provided an example:

> It would get to the point that when you had that typical train problem . . . you know the one that asks you what time would a train pass another train if one left at two o'clock in the afternoon and the other train (that was red and only half full of passengers) left at seven, what time would they pass by each other . . . I would scream, 'Who cares, am I on that train? NO!'

The real-life connections cited by participants were uniformly viewed as positive. A few examples include, at the elementary level, playing store to learn to balance checkbooks, and, at the junior high level, an egg simulation where students were required to make mathematical projections regarding their "babies'" needs and schedules. Of her high school teacher, NL pleasantly recalls: "He made math real to me by relating it to everyday life and real world situations. This teacher made me feel like a winner, and this was a very new feeling for me."

In sum, as a result of many years of formal education, participants can, with help, distill notions of what it means to teach well. These notions are consistent with many current recommendations for mathematics education.

Educational Implications

This study offers a multifaceted portrait of the knowledge, values, and beliefs that prospective elementary teachers bring to their credentialing program. Implications for teacher educators are clear. First, as previously noted, one teacher can have a long-lasting impact on a student's outlook on mathematics. Given this, it is imperative that we address issues of math anxiety, negative feelings towards mathematics, and limitations in content knowledge to avoid the negative power of one teacher taking hold. Helping our prospective teachers link effort and performance to their notions of competence seems to be an important step. Through simple line graph (attitude versus performance) assignments, such as those presented in this study, student teacher candidates can begin to unpack and address negative feeling towards mathematics.

Second, if these participants are representative of our nation's future teachers at large, we may predict continued limited conceptions of mathematics without a clear focus on problem solving or conceptual understanding. Indeed, in the most recent NAEP study, just one-third (36%) of U.S. fourth graders correctly solved a story problem using multiple operations. Only a small fraction (6%) of U.S. fourth graders applied their understandings to complex and non-routine real-world problems (NCES 2007a, 2007b). Teacher education programs need to consider restructuring both prerequisite course requirements and methods courses curriculum to guarantee the inclusion and focus of these crucial areas. Thus, we will need to continue to search for opportunities to enrich prospective teachers' notions of mathematics and their mathematical competence.

Third, it seems imperative, especially given the short duration of most mathematics methods courses, that we carefully consider the goals and opportunities that drive our courses. By doing so, we might determine the most influential points for intervening to change classroom practice and enhance instruction and learning. As we help our prospective teachers consider what it means to teach mathematics well, one promising course of action might be to help teachers surface and systematize their own lived experiences to define good practice and then to help them connect those fairly well developed notions of practice with other enriching information. Reflection in some form is one key to unearthing and utilizing the positive instructional influence and moving past the negative impact of previous teaching and learning experiences.

Prospective teachers do, indeed, spend time learning some negative things through the school curriculum, but this study suggests that prospective teachers also have a rich store of intuitive understandings about mathematics teaching and learning that could be tapped to facilitate the construction of theoretically sound, research-based practices in mathematics education. Because research (Grant, 1996) argues that methods classes can indeed positively affect teachers' performance, this study and others like it (e.g., Ellsworth & Buss, 2000; Rooney, 1998) suggest that helping teachers to surface and analyze their mathematics stories can serve as a powerful starting point for in enriching their understanding of what mathematics *can* be and do.

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Appendix

Personal Mathematics History Assignment

Teachers are affected, often dramatically, by the life experiences that they accrue long before they enter a credential program. Over the course of the year, you will *be asked to reflect in writing on your personal history in general and as it pertains to many subject areas in particular.* Please compose your autobiography as a mathematician, that is, as a learner and knower of mathematics. Go as far back in your own life as you can recall and include information that you see as pertinent from both in-school and out-of-school experiences. You may wish to consider people and experiences that had strong effects on you, whether those effects were positive or negative.

Although there is no set length for your autobiography, it would be hard to record your history in fewer than two pages. The format of your autobiography is your choice. Please bring a hard copy to class on the due date to aid class discussion. In class, we will discuss the implications of autobiographical information and how we can obtain similar information from our students.