**Math I Am: What we learn from stories that people tell about math in their lives**

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## Introduction

What is mathematics? And what counts as mathematics in people's activities at home, work and school in daily life? One might try to answer this question by consulting expert mathematicians and philosophers, or by examining the historical role that mathematics has played in shaping major scientific and technical advances. We take a far less lofty approach, and try to find answers to this question in the everyday experiences of adults and children. Without denying the possibility of a universal mathematics, we assume that the question, *what is mathematics,* may garner markedly different answers from person to person, and therefore the meaning of mathematics may vary from person to person and from context to context.

We might expect many families to deny any mathematical involvement, except in school and certain professional contexts. Or families might report engaging in a very narrow slice of the mathematical world, such as counting change at the grocery store. Or, they may report broad participation in mathematical activities across varied contexts. In order to find out how different families perceived mathematics in their lives, we asked family members to tell us stories about their mathematical experiences.

Through stories gathered from interviews with 20 families reflecting the ethnic, racial and economic diversity of the San Francisco Bay Area, we investigate the diverse contexts and activities in which families engage. We are especially interested in understanding how and when mathematics plays a part in these contexts. We seek to characterize the structure of mathematical activities, describe the resources that are brought to bear, and analyze the contributing social conditions and arrangements. Ultimately, we hope to understand the ways that family life is rich with mathematically relevant thinking and problem-solving and to identify possible intersections between math in the home and math in the school (Goldman, 2005).

We base our analysis on a set of "Math in a Minute" (MIAM) stories we collected near the beginning of our interviews (described in detail below). We asked each family member to tell us a story from their life involving mathematics. These stories offer a glimpse into people's views of mathematics – what it is, what role it plays in their lives, and what is a reasonable way to tell a

story about it. We find that families described mathematical experiences across a wide range of activities. The stories they told reflected their conceptions of what mathematics was, and their conceptions of who they were as individuals and as a family.

The stories are, as we hoped, both personal and mathematical. As such, we found that when our interview participants reflected on math, they also considered how their math reflected on them. The two questions, "what is mathematics," and "who am I, (and who are we, as a family) in relation to mathematics," are the two foci around which we form our analysis in this chapter. In tackling these two questions, we make specific for mathematics the general observation for learning theory that "learning to know" and "learning to be" are intertwined: "What people learn about, then, is always refracted through who they are and what they are learning to be." (Brown & Duguid, 1996, p. 138; also see Lave & Wenger, 1991). Because we asked people to tell personal stories, their observations about mathematics and about themselves were tightly interconnected.

**Methods**

The paper is based on interviews where we sought narrative accounts of math in people's daily lives. Narratives provide us with participants' accounts in their own words about their lives and mathematical activities. The total number of persons interviewed was 71 and included 35 children in 20 families. The families represented a spectrum of racial and economic diversity, with parents' educational levels ranging from some high school education through graduate school. All of the families included at least one child in middle school at the time of the interview, and we were interested in how students at this crucial juncture were experiencing mathematics at school and at home.

*The Interviews*

The MIAM stories were gathered as part of a semi-structured interview designed to generate conversation and elicit accounts about family members' uses of and experiences with mathematics. The interviews were meant to prompt discussions of the activities that families engaged in as part of family life, work, and school, allowing them to provide particularized versions of how they thought about and accomplished each life task (Linde, 1988; Plath, 1980). The interview was conducted with all available family members and two or more interviewers (including one camera operator).

The stories were collected early in the interviews, and were meant to be ice-breakers that allowed family members to talk about math in their lives before our interview prompted them to talk about specific family contexts and activities. We asked for a story involving math, good or bad, from any setting, including school, work, and home, that would take about a minute to tell.

This task enabled each family member to relate to math in his or her own way. Math in a Minute stories covered all kinds of territory, from how people felt about math in home schooling, to how people felt when they failed in school math, to how they used math while fixing something around the house.

To help interviewees understand the task, interviewers began by telling an example MIAM story that did not involve school math. Each interviewer told a different story, about a recent experience. For example, one interviewer discussed helping some friends lay laminate flooring and the mathematical challenges involved in the project. Each interviewer's story undoubtedly influenced some of the participants' stories, perhaps by eliciting many non-school math stories (as intended), and likely in other subtle and idiosyncratic ways. Some family members followed on the interviewer stories through associations they made with them, but generally, the interviewer stories were not out of the common range for math-involved descriptions we heard in other parts of the interviews. Likewise, because family members told stories sequentially, they influenced each other's stories. We take this interdependence as an interesting finding about how families tell stories (and perhaps as a clue to how family members are socialized into their understandings of mathematics).

Some stories were co-constructed by several family members, especially children's stories. Younger participants sometimes hesitated to offer a story and were prompted in a general way by the interviewer or for a specific story by an adult family member (e.g., "remember the time we made the curtains?"). Also, although at times the interviewer participated in a family discussion of the mathematical content of a particular story, the stories themselves were always chosen by the families first. So, although the stories and their interpretations of mathematics were influenced by the interview setting, interviewers and other family members, the choice of stories still reflects how participants represented situations in their lives in which mathematics played a role.

The interview went on to focus on different areas of family life where mathematics commonly appears (e.g., home improvement and repair, budgeting, shopping). We asked families to tell us about their experiences in these areas. Although in this part of the interview we did not specifically ask for mathematical stories, participants did focus mainly on mathematical aspects of their participation.

The analyses of the MIAM stories proceeded through several stages and data generation activities. Six team members completed interpretive analyses to identify characteristics of people's math depictions. For example, early on we noted particularly salient differences between stories told about school math and those told about math outside of school. That led us to create two groups of stories – what we call 'school stories' and 'home stories' – and search them for commonalities and differences based on emergent features, characteristics and themes. We take the categories of home

and school stories separately, answering the questions of "what is math? and "What does this story of math say about me as an individual or us as a family?" by comparing and contrasting their characteristics. Families told between 1 and 5 stories, with a mean of 3.55 stories per family. Table 1 shows the number of stories we collected in each category.

Table 1. Number of Stories per Category.

| *Category* | *Number of Stories* |
|---|---|
| Home | 49 |
| School | 22 |
| *Total* | *71* |

The MIAM stories represent a powerful setting in which to analyze the family stories; since we asked participants to tell a story about mathematics, their stories highlight what counts as math for them (in the context of the interview), as well as how they used mathematics to tell us something about themselves and their families.

**(Mathematical) identity and narrative**

The math stories we were told were not neutral, factual accounts of events people had experienced in the past. They were often emotional and evocative, whether they were told by children or parents, or about home or school. They were often tied to statements about the "kind of person" someone was, and they often related, both in the content of the stories and in the way they were told, to the ways people expressed and experienced their "togetherness" as a family.

These aspects of the MIAM stories pertain to their status as stories, albeit stories that were told in an interview situation. All stories are told in order to accomplish something – to present a view of the world, to entertain, to convince, to paint a picture of one's self or one's acquaintances (Schegloff, 2003). Some have argued that people construct their identities through narrative, and that in telling stories, they create and modify the identities available to themselves and others (Drake, Spillane, & Hufferd-Ackles, 2001, drawing from McAdams, 1993). We do not assume that the stories in our interviews reflect enduring self-portraits of this kind (although some of the stories may have done so); instead, we focus on the way the narratives allowed our participants to present themselves as certain "kinds of people" (Gee, 2000).

Several studies have investigated the stories that people tell about *school* mathematics, and considered the relation of these stories to the narrator's ongoing identity construction (e.g., Drake, Spillane, & Hufferd-Ackles, 2001; Kaasila, 2007). These studies develop further the notion of the 'mathematical identity' (or 'mathematics identity'), a concept which has been variously defined. In

some work, one's mathematical identity consists primarily of a set of beliefs about oneself and about (school) mathematics (Martin, 2000). In another example, a mathematical identity consists of a participative "mode of belonging" related to one's participation in a mathematical community of practice (typically, the mathematics classroom: Solomon, 2007, drawing on Wenger, 1998). Note that this second example considers what people *do*, in contrast to the first, which considers what people *think*. A third way defines identity to be the set of stories that we tell about ourselves (Drake, Spillane, & Hufferd-Ackles, 2001; Sfard & Prusak, 2005) – forming a middle ground between thinking and doing, as stories are not stories until they are told to another.

Debates around appropriate definitions for identity continue in the scholarly community, and we make no attempt to resolve them. In our analysis of MIAM stories, we do not need to rely on "what people believe" about mathematics or about themselves, nor do we argue that the stories in our data set reflect these inner beliefs. We do not have access to people's participatory identities because we did not observe people in action in a variety of settings. So, for our purposes, we consider storied identities, and how the stories that we were told provided a venue for our participants to construct such identities for themselves and for their families.

Stories can be used as resources for the identification and labeling of family members' personal characteristics (Gee, 2000; Holland 2001; Wallace 1967). In our data set, as we will see, family members self-identified ("I'm a responsible person," "I'm a numbers person"), labeled each other ("she's stingy," "she's easily frustrated") and co-identified in a myriad of ways ("we are that kind of people"). While it may not be surprising that narratives were used in this way, we found it intriguing that these stories of *mathematics* could be used as identity resources in such a wide variety of ways.

Another aspect of identity we wish to highlight here for our analysis is that because the narratives were co-constructed by multiple participants, including the family members and interviewers, so were the identities. That is, stories were used to create subject positions for one's self, for other family members present, and for story characters not present in the room (e.g., teachers, friends). These subject positions could be accepted and upheld, or challenged, modified, and altered as the story progressed.

With this chapter, we add to the growing body of literature considering mathematical stories and mathematics identities, through the consideration of these stories and identities *in out of school settings*. As we described above, a number of studies have undertaken the description and analysis of school mathematics identities. For example, Drake, Spillane and Hufferd-Ackles (2001) discussed three common story types (and thus, for them, identity types) for mathematics learners – "turning point," "failing," and "roller-coaster." We consider it reasonable that if we

broaden our examination of people's experiences to include experiences with mathematics outside of school, then we might find a broader set of possible stories.

The characteristics and themes that emerged around stories of math at home and work differed from those at school. Math at home was integrated with life activities, problem-solving, and people's values. [Footnote: We use 'math at home' as a shorthand for mathematics that occurs outside of school. By this definition, math 'at home' occurs in quite a range of settings, including stores, neighborhood locations, the workplace, etc.] It was employed to accomplish goals that mattered to people. At home, math was part of problem-solving and social activity, and with the exception of homework, was rarely depicted like math in school. As we will discuss, stories of school math more often involved external evaluation and outcomes which were right or wrong. Because of these differences, we specifically separate and examine the characteristics of math at home, and math at school, and consider how families depicted their experiences of math differently across these settings.

**Home and Math**

*"What is Math" in the family?*

One striking feature of people's home-centered math stories was the diversity of mathematics applications they contained. About half of these stories focused on a protagonist competently resolving a problem that presented some difficulty or unexpected complexity. In these stories, math was put to good use across a variety of important and valued activities, from measuring for home improvements, to budgeting, to figuring out best value while shopping, to deciding what college to attend. Some of these stories, such as one-time home improvement projects, involved substantial novelty. A second type of story accounted for about one third of the stories. These stories focused on routine mathematical tasks that family members faced at home. They did budgets over and over and claimed that they always did them in the same way. Like Lave's (1988) shoppers, they figured out what for them was the best value in items to buy in the supermarket. They approximated or always used the same proportions of ingredients when they worked with recipes. In other cases, math was put to use playfully, in games and puzzles, where the problems needing solving were invented for fun. Across these examples, math was embedded in solving problems that mattered to people, with the problems themselves driving the activity.

Diverse kinds of math. People told us about many different kinds of math. They created and maintained spreadsheets, and they used calculators and on-line tools. They rounded and estimated, worked with ratios and proportions, thought in two- and three-dimensions, and worked with patterns, geometry, algebra, multi-variable analyses, and logic. For example, one family described a kitchen cabinet remodel which involved balancing multiple constraints, including

commercial constraints (a desired corner cabinet only came in one size) and usage considerations (the best placement of the dishwasher for efficient work flow in the kitchen) that in turn led to two- and three-dimensional geometric constraints (what to do with an awkward six-inch gap, to make it usable), which then led to balancing financial constraints (the most attractive option for the gap, a spice rack, was also the most expensive, which had to be balanced against other expenses and a desire to avoid wasted space), all among conversions from metric to standard units, within the broader context of trying to create an attractive kitchen space. In this and other examples, people brought figuring and thinking together to solve problems alone and with others. Even so, they consistently privileged their memories of the situations over the math.

Interestingly enough, people had little trouble identifying stories to tell about their mathematical experiences. Their descriptions revealed a great deal of mathematical thinking, processing and communicating. Almost all of the stories described these processes in positive ways. Math was part of being competent in their lives, and there was usually no single criterion for what counted as success. If they tried some mathematical strategy, and, if it didn't result in an adequate solution, they did something else. In these stories, mistakes were not necessarily without cost, but many settings were forgiving enough to allow second and third tries. For example, recognizing that they might measure incorrectly while wallpapering, families could purchase some extra materials in case of mistakes. If they could not buy the clothes they wanted on sale, they could buy one less item to stay within budget.

Math at home stories are social. Although some stories involved individuals, at least half involved multiple people in mathematical problem-posing and problem-solving. In one family, the father, Andre, was in charge of budgeting. The mother, Nia, wanted to re-tile the bathroom, and she knew she had to figure the costs before proposing the idea to her husband. Nia built an accurate 3D scale model of her bathroom using cardboard in order to figure out how many tiles they would need, and she got help from the person in the tiling shop to estimate the total cost. She was delighted that the person in the store was able to estimate accurately the cost from her model. She recounts, "the measurements were all precise, and the number of tiles – you could tell how many would be per square foot. So that was, that was fun." Armed with the cost estimate, Nia and her husband could now discuss the renovation project. The story involved three people over the course of several days and settings, figuring and communicating around the model, tiles size and prices. Nia seemed absolutely delighted to share this co-produced and successfully solved problem with us.

Getting it done instead of getting the right answer. Another feature of math at home is that "right" and "wrong" are relative, not absolute. When Nikhil, a middle schooler, created a comparison chart to show his parents the differences between buying a hybrid or a conventional

car, it mattered little if the purchase prices and gas consumption rates he gleaned from a news article were exactly right, as the structure was created to support a whole-family conversation about whether or not to purchase a hybrid. They could discuss whether all of the gas mileage information was correct and find more detailed information as needed. Similarly, another family told a story about covering a cylindrical birdcage with chicken wire so that a smaller bird could not escape. The project required measurement and geometrical reasoning for turning 2D wire into a cylinder shape, but fine precision was unnecessary, and measurements and calculations could be approximate. In the end, it was completed to satisfaction with approximation.

Math as part of fun. Finally, we saw that math could be part of family fun. Sometimes there was a multi-generational relationship around mathematics. In one family, the mother described how she and her father used to play math games together when she was a child. Her father would make up silly math story problems, which she would try to solve. Now that she had children, her father played math games with his grandchildren over phone and over email. The granddaughter, a middle-school student, credited these games with shaping her relationship with mathematics, saying, "I think that encouraged me to like math."

Several families also mentioned using time in the car to do math together, playing math games or encouraging the children to calculate how long it should take to get to their destination given their current speed. The Echevarria family created a travel journal when they took car trips together, recording how many miles they drove each day. At the end of the trip they added up the total miles and they compared distances across trips. On a trip to Toronto, they used their previous trip to Las Vegas as a unit of measure. They told us they figured they had driven about the distance to Las Vegas every day of their trip. Both of these examples blur the boundaries between our 'home' and our 'school' stories, in that the mathematics problems were school-like in a dual sense: focused on either computations purely for the sake of computations or school math applied in novel settings. Although we can't be sure, we suspect that adult family members may have had pedagogical intentions as they embedded mathematics into the fabric of family life.

Other examples of family fun included board games and hobbies. In one family, the father and daughter worked together to program a computerized game spinner so all three family members could play a game that usually required one person to stay out of the game to spin. A middle schooler in another family, Gaurav, enjoyed making complicated projects out of LEGO blocks and during the interview got into a discussion with his family about whether his hobby involved mathematics. Another boy frequently checked the statistics of his favorite NBA star. A middle school girl described using math in her sewing hobby at home, and discussed how learning dimensional analysis

at school was like a "door opening" to help her convert between units of measurement. In all these examples, mathematical reasoning was part of activities people enjoyed doing.

In sum, math in the home was used to help people with some problems that were routine and some that were unusual, some that were simple and some that were complex. Most of the stories portrayed successful problem-solving. Math was integrated in social activity among family members and others across a variety of contexts. Math was forgiving in the home context. It did not always result in absolutely correct answers, and people did not often speak of being evaluated by others or evaluating their math performances. When evaluation was prominent, it was usually the task itself that was evaluated, not the specific mathematical techniques. People depicted math as integrated into their activities, so that they were not always sure it was math.

*How math relates to the question of "Who am I?"*

When people told us quick stories of mathematics, they not only identified what they thought math was, they also used the stories to tell us about who they were. As we discussed earlier, math was not a neutral subject for people. Their MIAM stories were accompanied by emotion, statements about their values and ethics, and statements about the "kind of person" they were. As such, these stories sometimes invited participation by other family members, through prompts, elaborations, or corrections. The stories labeled traits, and people told how us how they or others were "cheap," "stingy," "frustrated" by math, or a "brain." Stories were occasions for being patted on the back by others, but they were also sources of bad memories and experienced conflicts. Our participants told us about math in their lives and how it revealed characteristics of the family and its members.

Several themes relating to individual and family identity arose in the stories about home, including math as part of developing character or personal responsibility, or fulfilling social goals and responsibilities. Mathematics was part of what families do together and integral to their shared experiences.

<u>Being personally responsible</u>. Several of our MIAM stories described math in the context of helping to develop personal responsibility, particularly as related to budgeting and finance. For example, in the Echevarria family, the father described how he and his family used math to determine whether they were making financially sound spending decisions, considering how much the family had to spend, as well as whether the item was a good value. "Is this too much? Is this appropriate? Do we need it? Basically, it's math." For the father, these decisions were an attempt to balance the family's needs with the desire to be financially responsible.

Related to this example, we also heard several stories involving parents giving their children money to spend. These practices seemed to be intended to teach children about staying within a budget and making responsible decisions. In one family, Hannah, who was in middle

school, wanted to buy a dress for a father-daughter dance. The dress she liked was on sale, and she described how she calculated the percentage off to see whether it would fit within her budget.

Nia's elementary school daughter Giselle told us, "When I want to buy something I always have to think about how much money I still have to spend." Giselle's middle school sister, Brianna jokingly described Giselle as "stingy," and said that Giselle often got "discombobulated" when she made a decision about spending her own money, especially when Giselle considered how much less she would have after the purchase. Her father Andre added, "they learn quickly, that, you know, if it's their money, then they get really stingy and very conservative." When Nia chimed in, "But when it's our [money]…," the family laughed. In these stories, children were learning to make value trade-offs when spending their own money. This theme was echoed in several of the stories. A father named Harold formalized the process. "It's interesting because they do, in theory they do a value-cost analysis in their head. They'll see something, and they'll say 'I want to buy this. How much does it cost?' So we find out. And [both children] say, 'you know, for four dollars, I don't want it. It's not that important to me.'"

Being socially responsible**.** Several of our MIAM stories blended talk of mathematics with talk of social or community responsibility. One mother, Swati, described how her financial discipline, combined with her shopping and budgeting prowess, allowed her to help her community. Swati had a weekly grocery budget, but typically ran under budget, and donated the excess money to charity or the church, something that she said made her proud. Her husband, Rupeni, described how Swati always knew which stores would have the best deals on which items, and she frequently bought in bulk. Swati also described her practice of buying necessities well in advance, so she would never need to rush out and pay full price. "I'm a good housewife. I do well at home. I know where to save money and how to save money." Swati credited her shopping expertise and discipline in not indulging in unnecessary expenses, such as pedicures or eating out, with allowing her to donate money to the community, which made her feel good.

Swati's husband Rupeni also talked about how math helped him fulfill his social responsibility to his extended family. As a young man in Fiji, Rupeni's family owned a grocery store. Rupeni described how if they started with $100 worth of goods one week, they would rollover their profits and buy $200 worth of goods to sell the next week, and so on. In that way they built their store. But, when extended family members came to the house (which was a frequent occurrence), they needed to use supplies from the store to feed them, and they would not make any profit. They recuperated their costs by charging interest to customers who needed to buy goods on credit. In that way they were able to feed their extended family, and still balance the costs of the store.

In another family, Tania described how she hoped to use her math experience and math teaching supplement to fill an important need for English language learner (ELL) students. Tania had recently transitioned from a job as a construction inspector to a teaching job. Tania hoped to teach Algebra 1, something she saw as the greatest need for ELL students. The principal assured her that she was a perfect candidate for the math position, but at the last minute Tania was assigned to teach Spanish instead of math, which surprised and disappointed her, as she felt teaching Algebra was an important way she could make a difference in her community.

We also heard stories from children describing how they used math to contribute to their communities. For example, one middle school girl talked about how math came into play when trying to create a quilt for needy children. One challenge involved subtracting a half-inch on every side to leave room for the seams. Across our stories, we were surprised at the number of examples of people using math in service of the community.

Being a family together. Another theme that stood out to us in the MIAM stories was how much math was a part of the family's shared experience. Families frequently described doing math together (with over half of the stories involving multiple people jointly solving a problem), and in the telling of the stories, family members chimed in and embellished each other's accounts. It was evident that some of these stories had been told before and were enjoyed by all those present. In such cases, family members sometimes interjected what they saw to be general characteristics of the person telling the story and their relationship with math. For example, in one story, the grandmother, Barbara, described getting a good deal on her cable bill. Her grandson jumped in and said that deal finding was something she was very good at, indicating that her deal finding skills were known throughout the family.

Sometimes attitudes toward mathematics and problems solving could be seen intergenerationally and at the family level. For example, a mother, Mahita, described how her family did not like to make major decisions based only on emotion. So they often tried to "translate a lot of things into numbers" to come to a more "objective decision". For example, when her children were young, she and her husband had to choose among three places where they wanted to move. They decided what criteria they cared about for quality of life (e.g., education, culture, weather, etc.) and gave each place a score for each criterion. In making their decision, they compared the scores across the three potential locations. In response to this story, the older daughter, Tara, described a similar numerical scoring process she went through when choosing which colleges to apply to. In the telling of the story, the rest of the family members chimed in about how the scoring system worked. This method that we now call "multi-attribute utility theory" was first described as an algebra to support decision-making by Benjamin Franklin.

Home and math identity. Family members' participation in mathematical activities encouraged the development of identities that went beyond being good or bad at math. For example, Swati described herself by saying "I'm a good housewife", in part because of her ability to stay under budget and give to charity. Similarly, because of her difficulty making purchasing decisions with her own money, Giselle's family jokingly called her "stingy" several times throughout the interview, such as when she was describing her Monopoly strategies. In other families, Gaurav, who enjoyed building with Legos, was known as being good at "figuring things out", and Barbara, who was able to negotiate a cheaper cable rate, was known as a bargain finder.

In addition to the development of different roles within the family, we saw attitudes toward mathematics being carried down from generation to generation. In one family, playing math games with grandpa over email encouraged a positive attitude toward mathematics. In another, the daughter took a similar "objective" approach to making decisions by translating evaluative criteria for alternative decision choices into numbers, as her parents did years before. In several stories, parents encouraged the development of responsible attitudes toward financial decisions in their children by giving them control over spending their own money. Across the MIAM stories, participating in mathematical activities helped family members develop a sense of "who am I?", that went beyond being someone who was good or bad at math, to encompass issues of personal and social responsibility, as well as roles and characteristics, and attitudes toward mathematics.

**School and Math**

*"What is School Math?"*

Not surprisingly, many Math in a Minute stories involved school (approximately one third of the stories). School stories told by adults especially, were often specifically about experiences in mathematics classes. (All 8 school stories told by adults were about experiences in math class, versus 10 out of 14 by children.) As such, the question of 'what is math' was tied up, at least implicitly, in school-based definitions of mathematics and mathematical activity. It is easy enough to imagine what this "math class factor" might mean for people's understandings of what math is. Any one of a number of vices (authoritarian, formulaic, anxiety producing) or virtues (rigorous, elegant, powerful) of school math might exert their influence on people's conceptions. We examined the stories for specific evidence of how school stories were distinct from home stories.

Generalizing about experiences with school mathematics. Eight of the school stories involved general talk about 'getting it,' or 'not getting it,' or about a great math class or a terrible teacher, without addressing specific mathematical problems or topics. Four of these stories were negative, and four were positive. All eight cases either explicitly or implicitly involved a teacher

or other authority figure evaluating the storyteller. For example, the grandmother in one of our families, Loretta, told a story about how she hated math as a child. She told us of a time when, in high school, she received an 'F' in math, and when the report card arrived at home, she secretly changed the 'F' to an 'A.' She said the bad grade was traumatic, as she was a good student and got good grades in her other classes, and in the interview told us that after receiving that grade she never took a math class again.

Loretta's daughter Alisha followed with a story about struggling to help her son Marcus do his mathematics homework, in spite of her own dislike of math. This story cycle continued when Loretta mentioned that Marcus was really good at math. At the same time, Alisha suggested to Marcus that he used to like mathematics, but did not like it any more. He protested that he did like mathematics, and that he was good at it. To emphasize his point, he produced his school progress report and showed it to his grandmother. In each of these stories, math was described in the most general of terms, with no differentiation among its varieties, and the emphasis was on whether one liked or disliked math, as well as whether one was 'good' or 'bad' at math.

A more positive, but still quite general story was told by Brandon, a young participant who had attended a 'Physics Day' at a local amusement park. He was proud that he and his classmates were the only sixth graders there, whereas the other participants were high school students. The implication was that Brandon and his classmates were doing more advanced mathematics than others their age. A similar experience concerned a more advanced mathematics course, as told by Harold. He recounted his calculus experience by retelling the fun he had as he suddenly realized all the things that he could do with calculus – calculating volumes of cubes, how much water goes into a shape, and so on. Harold likened his experience to 'a light going off' when he began to realize many things about mathematics that he hadn't known before. He then explained that when he 'coached' his own children in geometry, he wanted to make that light go off for them. His wife Harriet, in contrast, told us about when she took a semester long accounting class in graduate school and really struggled with the mathematics, in part because she could not understand the instructor. Harriet described the content as 'hard,' even more so because of the instructor, but did not provide any more detail about the mathematical challenges she faced.

Evaluation by a teacher or other figure was less prominent in these three stories, though in all three of them, teaching and teachers played a central role. In the amusement park story, Brandon talked about asking questions of teachers to help him solve the calculation problems he had to do. The calculus story was introduced by Harold discussing how he liked to coach his children so that they would experience the fun of mathematical 'lights going off.' Harriet's

accounting story was all about the perceived shortcomings of the instructor. In these general stories about school experience, teaching and evaluation were central.

Math as specific problems, teachers, and grades. In addition to the more general stories just described, there was also a set of eight school mathematics stories in which people explained a specific problem that they were trying to solve, their methods of solution, and how their solution was evaluated by others, especially the teacher. One young person, Felix, described a problem that involved dividing a cake five ways so that there were equal amounts of frosting and cake. Felix devised a creative solution, saying that he would initially separate the frosting and the cake, divide each of those into five equal pieces, and then pair the cake and frosting back together. The teacher disagreed with Felix's method, saying that it violated common sense. Felix felt that the teacher's assessment of his solution was wrong, and that he had actually followed the constraints of the problem.

Victoria recounted a specific event with a stronger negative affect. She remembers being given a single-digit multiplication question by her teacher when she was quite young. Victoria said that her teacher had been "a fierce old lady," who "whacked" her on the knuckles when she gave an incorrect answer. Victoria continued her story by explaining that this experience stayed with her for a long time and affected how she felt about mathematics in general. Her daughter Madison, in turn, told a story about doing sets of division problems in school, and being proud of being the fastest in the class in completing problem sets. Madison's brother Jay, who was a little bit older, interjected to boast that he was even faster than his sister.

In a different family, one of the children described how his desire to "get to the next level" on timed multiplication tests was thwarted by his teacher, who said he was not ready, even though he had met the criterion they had previously agreed upon. Jay had also complained that while his class learned fractions by doing boring worksheets, another class learned fractions using graham crackers and icing. He thought it unfair that some children got to learn math by using food while he languished in a world of worksheets. In these stories, math was a source of either positive or negative feelings (more on this below), but in each case the mathematics was intimately tied up with issues of authority and evaluation.

Math for math's sake**.** One salient factor common to the majority of these stories is that math learning was the primary focus. Mathematical activity was an end in itself. This finding is not surprising, since the stories took place in school mathematics classes. It provides a stark contrast with the home stories, where mathematics was a means to an end rather than the focus of the activity itself. While the home stories generally focused on math in service of a particular goal, the school stories were about the math experience itself. In particular, the explicit focus on

mathematics as an end in itself provides a partial answer to the question, 'what is math?' namely that it is something to be pursued in its own right.

This pattern was not without exception, as we collected several stories in which math appeared in other school subjects as a means to non-mathematical ends. For example, Darren, a middle-school aged participant described a project he had done for one of his classes, in which he had decided to make a poster that was shaped like a pyramid. His story recounted the challenge of constructing this difficult shape. Although mathematics was at the foreground in the telling of the story, the actual purpose of the activity was just to make a creative poster; mathematics in this story was used as one tool to achieve these ends. We also heard stories from two families about time management and homework, where the young protagonists discussed having to budget their time so that they could get all of their homework done. In their stories, mathematics was used as a means to an end, but was not as an end in itself.

In summary, school stories painted a picture of mathematics as something requiring an ability of some sort (for it is possible to be bad at it), as something to like or dislike, as something that institutions and their agents (especially teachers) have special authority over and as a potential source of pride or trauma. Math was primarily portrayed as something to be studied as a free-standing entity. Stories of mathematics as a tool for accomplishing quantitative goals were rare, especially in comparison to their prevalence in the sample of home stories.

*How math relates to the question of "Who am I?"*

One of the notable features of the school stories described above is that so many had a significant emotional component, ranging from like to dislike, from pride to shame. In addition, these stories were an occasion for interview participants to describe themselves in terms of their math competence, reporting that they were 'good,' 'bad,' or even 'terrible' at math. While in some cases these self-identifications seemed relatively static and long-term, our dataset suggests that a view of mathematical identity as individual and enduring is too simplistic. As discussed in the introduction, we use the term identity to refer not only to people's *beliefs* about themselves in reference to mathematics, but to the ways in which they are socially and situationally positioned with respect to mathematics.

School and math identity. A number of our stories exemplify the shifting and socially constructed nature of one's mathematical identity. For example, in the Medrano family, it was taken for granted that the middle-school-aged boy, Ismael was good at math. Ismael told us this directly, and his mother and sister both made reference to Ismael's mathematical competence. Ismael sister's math-in-a-minute story showed a much more complex mixture of confidence and uncertainty. Leticia began by reporting that her teacher told her to be careful with her 'steps'

when she solved problems, because Leticia was not as good at math as her brother Ismael. The rest of her story was about helping her classmate with math, and Leticia appeared to be proud of her ability to help another person solve a math problem on the geometry of parallelograms. When asked her to show us how she solved it, and she began to write out the problem, but when the camera moved closer to capture what she was doing, Leticia covered her work with her hand, perhaps out of shyness. After a brief reassurance, Leticia continued, and she and Ismael spent some time discussing the purpose of the problem, finally deciding that the goal was to determine the area and the perimeter. She closed by saying it was not hard to teach her classmate about how to solve the problem..

We do not wish to over-interpret such examples, as a few minutes of storytelling can only shed so much light on important theoretical issues concerning identity. Nonetheless, is it remarkable that so much – from unequivocal assertions of competence, to softer mentions of mathematical accomplishment, from the pride of helping to the embarrassment of doing math on camera – can be seen in such a brief snippet of storytelling. Mathematical identities need not be as straightforward as they may appear from stories of being 'good' or 'bad.'

These stories also amply demonstrated the social and situational nature of mathematical identities. Earlier in this paper, we discussed how Marcus was variously positioned by himself, his mother, and his grandmother in terms of his feelings about math, demonstrating that even within a family, mathematical social identities could be controversial. Alisha's story contrasted her general dislike of math, as a student, with her strong desire, as a mother, to learn and understand mathematics well enough to help her son succeed in school. The role math played in her identity was not unitary or monolithic, but closely tied to the social roles that she (and that mathematics) plays in everyday life.

These stories reveal how mathematical identities are social and situational. They are also historical. In another family, one man's MIAM story about a difficult budgeting job at work quickly transitioned into a reflection of his own mathematical history in school. He recalled a specific word problem from his high school math class as an example of the curriculum, one which he felt did not adequately prepare him for college mathematics. His story, as brief as it was, was populated with people and institutions whose definitions and expectations of 'what math is' persisted over time as important elements of his mathematical identity. His memories are reminiscent of the literary theorist Mikhail Bakhtin's (1981) concept of "heteroglossia," in which the self is conceived to be literally peopled with memories of past interactions with significant others that continue to live on in present day thinking, feeling, and interactions.

To summarize, the nature of the math-related identities revealed through school stories were intimately related to the nature of the mathematics they described. Since mathematics in the school stories was strongly tied to teaching and learning situations in which evaluation was central, our participants reported math-related identities also related to being a teacher, a learner, and a person evaluated by others. Across the stories, other people's opinions about one's math competence – especially a teacher's opinion – had an effect on identity and on subsequent life choices about whether or not to pursue further mathematical study or careers.

**Design implications of the MIAM stories**

The mathematical stories we elicited from families varied in mathematical content, in terms of whether mathematics was a means or an end, and in implications for one's identity. One striking distinction between the stories of math at home and the stories of math at school was that the home stories were overwhelmingly stories of using mathematics *competently* to achieve desired ends. Whereas school stories were mixed, all the home stories were quite positive, even for family members who recounted difficulty with math in their school experience.

People were able to draw on their school mathematics learning experiences to solve problems encountered in daily life, and their accounts of solving the problems of home, hobbies and work were in fact more successful than their stories of solving the mathematics problems of school. Given this finding, we would argue that stories of mathematics at home provide a candidate model of mathematical success. From this model, we may draw some tentative design implications for more effective mathematics instruction in schools.

The stories of home math described situations in which there were a wide range of allowable solution methods and resources, more so than in the stories of school math in which featured teachers prescribed which solution paths were allowed. Problem solving practices in the home were social, involving multiple people and tools as resources. Family members often had multiple opportunities to try to work out a solution, and if one problem-solving approach did not work out, they could try again in a different way. Consider the problem that one schoolchild reported, of having to divide a cake into five perfectly equal pieces – by the amount of cake and amount of icing. Not only is this problem unlikely to be encountered in the home, but if it were, multiple solution strategies would probably be allowed. If one used the child's strategy – to divide up the icing and the cake separately, and then recombine, one's answer would be perfectly acceptable. In a school context, the teacher placed restrictions on solution methods, so that the child's strategy was deemed incorrect.

With an emphasis on 'getting it done,' and not necessarily having a completely accurate answer, family members estimated or 'eyeballed', but still applied mathematical reasoning to

judge the validity of their results. In cases where careful measurements were required, people were up to the challenge and used a number of carefully constructed representations (a 3D model, a scale drawing) to ensure accuracy. Yet even in these cases, our family members described how they allowed for error in their calculations, by purchasing extra materials, by budgeting more than they needed, and so on. There was an adaptive flexibility to mathematics in the home.

Considering the nature of the problem-solving process in the home, we might consider designing mathematics classes differently so students would have access to more resources, and to more creative ways to solve problems. By allowing students multiple attempts to solve problems, we might alleviate the anxiety of being evaluated by others, and encourage more risk-taking and experimentation in their methods (Hatano & Inagaki, 1992). By allowing students to mathematize problems in multiple ways, we might find that different students in the classroom develop different kinds of mathematical skills, perhaps fostering some interesting discussions when comparing these multiple strategies (Lampert, 2001). These features are integral in reform classrooms that pursue mathematics learning by fostering mathematical inquiry and discourse (Yackel & Cobb, 2003), with collaborative activities (Boaler, 1998), or in model-building projects (Lesh & Doerr, 2003).

So far, our discussion of design implications has focused primarily on the resources and solution methods available for mathematical problems in school. A second provocative area of difference between home and school mathematics stories resided in the nature of the problems themselves, and how solving those problems reflected on people's developing identities. In stories of math in the home, we found examples of mathematics being used to support one's sense of personal and social responsibility. Family members used their stories to illustrate their sense of fiscal responsibility, caring for others, and desire for precise and thoughtful answers in the context of family values. In the school stories, people's identities were generally summed up as either 'good' and 'fast' at math, or 'bad.' Whereas in the school stories, a wrong answer might lead to a sharp slap on the wrist and public exposure as a dunce, in the home stories, a mistake often led to a re-evaluation of the problem and a second attempt. These are forms of accountability of very different types.

If school mathematics problems were more like the home problems, then mathematics would be introduced as one tool (among many) to demonstrate one's care and responsibility for the world, as in curricula focused on investigating social justice issues through mathematics (Enyedy & Mukhopadhyay, 2007; Gutstein, 2006), or project-based learning environments (Greeno & MMAP, 1998; Stevens, 2000). Students might be less likely to leave behind a difficult problem, saying "it's not for me," but instead might work with renewed efforts to solve it.

Another area in which we might learn from mathematics problems encountered in the home is the integration of mathematics with fun hobbies and activities. In low-risk settings like a

family car ride, parents and children engage in playful problem-posing and problem-solving activities together. These stories differed remarkably from a prototypical 'fun' school math activity – a competition – that serves mainly to differentiate winners (smart students) from losers (dumb students). In family math games, mathematics often served a valued end, as when one family created a computerized spinner so that everyone could play Twister together. When mathematics was the end goal of the game – like comparing distances on a long family road trip, or sending funny math problems to one another via email – problem-solving was supported by multiple resources, multiple people, and everyone had a chance to be successful.

Far from being mathematically barren spaces, we found that home environments abounded in mathematical activities that almost all family members participated in. The MIAM stories suggested some key differences in the nature of mathematics in the home and in school, differences that rebounded to influence people's socially constructed identities. School mathematics stories were often structured around mathematics as an end in itself, involving external evaluation. By contrast, stories of mathematical activities in the home showed how problem-solving was a social activity, involving multiple people coordinating activities over multiple contexts and with many chances for revision and success. These stories demonstrate how people structure their environments to maximize competent and successful problem-solving, and highlight the function of school mathematics in constructing success and failure that may not appear in other facets of daily life (Varenne & McDermott, 1998). As Lave (1988) and Saxe (1990) helped show us in the 1980's in their pioneering work on everyday mathematics, "understanding how successful mathematical activities work will ultimately contribute more to advancing effective learning practices than repeated diagnoses of failures" (Pea, 1990, p. 31).

Our data clearly show the importance of school math as a source for mathematical competence and mathematical identity. In considering everyday life as a model of successful engagement with mathematics, we hope to reveal aspects of everyday problem solving which, despite their promise, are often overlooked. Schools might become better places for thinking and learning about mathematics if they shared some of the meanings, the values, the social nature and the adaptive flexibility of mathematics in family life.

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