

*An*  
*Accidental*  
*Mathematician*

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# ***Introduction***

Autobiography  
of an  
Accidental Mathematician

## *The Early Years*

I don't remember math from my childhood. It had to be there, but it left very little impression on me, except when my mother, frustrated with what to her seemed either inability or laziness on my part, would stand over me and intimidate me into guessing answers. I have a vague, general recollection of a sense of dread surrounding supervised math homework, but I don't remember the specifics.

I started kindergarten in California in 1968. I don't remember much about it except my mother standing with me on the first day, pointing out a little boy who was crying, and telling me what a big girl I was for not being such a sissy. She didn't use those words of course. I don't remember exactly what she said, but I remember the message. I don't think I was inclined to be a sissy anyway. I was always one for new experiences.

I remember hitting my head on the corner of a desk once that year and being rushed up to the nurse's office. Apparently even minor head-wounds bleed a lot. I didn't understand what all the fuss was about; I felt fine. But my mother met me there and took me home. I still have the scar.

I remember my teacher, Mrs G., vaguely. I remember the classroom; I remember how you could go into it from the door onto the playground and out through the door into the hall. All the classrooms at my first school were like that. I remember the piano, and the day my mother came with some other parents and we all had strawberry ice cream. I could tell you even today where the bathrooms were and I remember what they smelled like. But I don't remember math.

In first grade we moved to the portable classroom. When I last visited that school about three years ago, it was still there. Designed for temporary use, it became as much a part of the school as the main building. Unlike a lot of schools that install them, in ours, the first grade classroom was the only one ever erected. I remember my teacher Mrs B. as well. She was short, petite, gentle, and smiling. But I don't remember math.

I remember Mrs L from both 3<sup>rd</sup> and 4<sup>th</sup> grade, Mrs M. from 5<sup>th</sup> and Mrs O. from 6<sup>th</sup>. I remember inciting a riot in 5<sup>th</sup> grade because I thought 5<sup>th</sup> graders should have the same playground privileges as 6<sup>th</sup> graders. I remember going to a special French class, although I don't remember what years that was. I remember the principal's office – not because I was a trouble maker, I hasten to add. I remember where the teachers' lounge was, and the auditorium. I remember flute lessons and four-square at recess, and cheese sandwiches for lunch.

But I don't remember math.

I do remember *liking* math in elementary school. I remember learning about sets. I have a hazy memory of doing homework from time to time, and although I found it a bit tedious repetitive, I didn't think it was hard, and I didn't resent doing it. Funnily enough, I don't remember homework in any other subject. I don't remember math homework very clearly, but when I think about homework from those years, math is the only subject I remember having homework in.

The exception was that report on Brazil. I think I remember that because my mother made such a big deal about it. I wish I still had it. It would have been a work of art when it was finished. I remember sitting over the open encyclopedia, reading about a country I had never even heard of, and writing out facts about a fantastic place so far away from me in so many ways. Under my mother's watchful eye, I'd have written something like:

Brazil has a population of 93,000,000. Like many South American countries, they speak Spanish. The Brazilian people work in industries such as agriculture, mining and manufacture. Its natural resources include Tobacco, Rubber, Corn, Nuts, Cattle, Rice and Cotton.

Not exactly, of course, but something like that. Mum would have had me extract the facts, then "helped" me express them in this grown-up way. At the time I just did what I was told, not even aware enough of her impact to be thankful that I was getting help with my homework. Now, I know that my way of writing and of speaking, especially when it needs to be done formally, comes directly from this influence.

My Brazil report had a map too. I remember making it. I probably traced it from the encyclopedia, but then I would have labeled it by hand, colored in the different regions, made a legend and a scale. Again, I don't remember the details, but I do remember doing it. The whole project would have been hand-written, in ball-point pen. That was the only way to do things like that back then.

I have no idea what grade I got on it, but having seen some of the things my high school students turn in now as finished projects, when they have access to the Internet and word-processing software on computers in every home, classroom and library in the land, I suspect I did pretty well.

I remember that one and don't have any proof I ever did it; I have no recollection of putting together the one I do still have. It's called "Leslie H. – Life in Pictures". Judging by the dates on some of the photographs, I must have done it in about 1973 or 1974, which would put me in the 6<sup>th</sup> grade. It's made of large pieces of construction paper folded into a book with a beaded macramé binding. Each page has three or four photographs, each carefully labeled with a caption. The first couple of pages are pictures of my grandparents and great-grandparents, and of my mother when she was about 10. The rest are loosely themed pages depicting life with immediate family or cousins or friends, with one page for hobbies and recreation, and one at the end for the family pets. The cover was clearly a labor of love. The letters of the title were stenciled on, then filled in either in different solid colors, or stripes and spots, or tiny little dots.

I also remember music. I started with the recorder in 3<sup>rd</sup> grade, then in 4<sup>th</sup> grade I took flute and played with the school orchestra. In 5<sup>th</sup> grade I borrowed my neighbor's oboe and managed to pick out a scale. I loved it, because it reminded me of the bagpipes, and I switched to oboe and played that through high school.

I spent seven years of my life at that school, marching in Hallowe'en costume parades, playing kickball (not very well), cleaning out my desk, losing my lunch box, and generally growing up. I think my mother still has my report cards. I was not a stellar student, but neither was I a poor one. I survived, and left without much ado in June of 1976.

But I don't remember math much at all.

That September I went to junior high, as it was called at the time, which housed kids in 7<sup>th</sup> and 8<sup>th</sup> grades. My misery began here as I mixed for the first time with others with more confidence, more money, and parents who brought them up to look with disdain on anyone they considered not of their caliber. Being teenagers, that disdain took the form of taunting and teasing. I didn't have a designer wardrobe, and the other girls made sure I realized that this meant I was well beneath them. Today, what I endured would be called bullying, but somehow, although I didn't like my place in the pecking order, I did feel that it was my place. It never occurred to me to complain about it.

In hindsight, I think I still feel that way. These kids were going to pick on someone. They had no self-esteem of their own; nothing in particular to be proud of. The only thing they really did have was their similarity to one another. They'd have picked on anyone not like them. I had a pretty low self-esteem then too, which made me an easy target.

I'd like to take a moment now and thank them. Enduring that at the age of 13 and into high school made me stronger. It's helped me deal with people who treat others badly, because I know how it feels to be on the receiving end. As an adult I know I don't have to put up with that kind of treatment, and I can and do call people on it. What amazes me is that adults still do it to one another. It's also made me very sensitive to others' feelings about themselves. As a teacher, especially a math teacher, this is a vital quality. It's what makes me good at what I do.

I did have friends as well, though, and one girl I met in 8<sup>th</sup> grade geography is still a good friend today. I had detention once for skipping class on "senior skip day" because I thought those of us in the last year of junior high deserved the same privileges as those in their last year of high school. Do you detect a theme? But I didn't get in trouble other than that, and I stayed away from the kids I didn't like as best I could. It wasn't all bad. I did gymnastics and ran on the track team, and I made up stories about boyfriends I didn't have.

I still remember my schedule for the first year of Junior High:

- English
- Geography
- Science
- Math
- P.E.
- Music
- French

It was the first time I had to go from classroom to classroom to get to my lessons, and I was afraid I'd forget where to go at any particular time, so I memorized the schedule so thoroughly that it's still with me.

I remember some of my teachers from this time. Mrs K. was my science teacher. I remember the classroom, with its high, black-topped tables, gas valves and Bunsen burners. I remember sitting on stools instead of chairs, rocking on one that was ever so slightly unbalanced, trying to make it balance on two legs, just at that point between sitting on *those* three feet and those *other* three.

I remember the snake. I was the only girl in my class who would go anywhere near it, and I loved to sit with it wrapped round my shoulders while we watched films. I

remember dissecting a cow's eye, and then a fetal pig. I remember being proud of how un-squeamish I was about it all. It fascinated me. The fact that my mother had worked in genetics before she got married probably helped me appreciate how things work rather than revile how we come by that knowledge. I inwardly shook my head when other girls squealed and giggled and "oh-gross"ed their way out of the lesson.

My father was instrumental too, in my thirst for knowledge, in that he was constantly encouraging me to ask "why?" and when I did, answering me as though I was a grown-up. I understood the basics of Newton's laws of motion by the time I was ten, although I couldn't have told you that's what they were called. Dad was in science too, a medical histologist.

My geography teacher was Mr. G. The kids all made fun of him. He was really old; he must have been at least 55. He turned a blind eye to most bad behavior, so I suspect he was near retirement.

Mrs T. was my P.E. teacher; I had Mr. G. for band, and Mme G. for French. My locker was up on the third floor, near her classroom, so I'd leave French at the end of the day, stop at my locker and head home.

I don't remember English. And I don't remember math.

After three years in junior high, I would move to the high school for 9<sup>th</sup> grade, but the school district was changing its grade system to keep up with the times and to accommodate a growing student population. The junior high would henceforth be known as "middle school", and it would take students in 6<sup>th</sup> and 7<sup>th</sup> grade instead of 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup>. So those going into 9<sup>th</sup> grade "moved up" with those of us going into 10<sup>th</sup>, which is why I was never in the youngest class at the high school.

In addition to the required classes in science, English, math and history, I took dance instead of P.E. I was in the orchestra, and I continued the passing interest in theatre that I'd begun in elementary school. I remember one of my English teachers, Ms D., because of her kind and gentle approach to teaching. I'd always known I wanted to be a teacher, but it was Ms D. that made me want to teach English. I remember where my locker was, at least one year. I remember the office and the library, the covered outdoor corridors, the band hall and the theatre. I remember Mr. H., the music teacher, very well and with much kindness. But I do not remember math.

I don't remember where my math classrooms were. I don't remember who my math teachers were, with one possible exception in junior high, and I don't remember doing math, except that one snapshot moment in elementary school when I was learning about sets. But that was all about to change.

## ***High School***

Not long after I started 10<sup>th</sup> grade, my family moved to a rural area west of Seattle. Although I missed my friends at first, I felt I was getting a fresh start. Nobody in my new school knew I was supposed to be a punching bag. I was never in the cool crowd, but I wasn't the brunt of abuse either, and it made a difference. I took drama with Ms W., which also helped my self-esteem immensely. My friend KC and I would have "practice fights" in the halls, where we'd scream at each other as though one of us had grossly

betrayed the other, then round the corner and fall into fits of laughter. Not now what I'd consider a tried technique for theatrical training, but it was great fun at the time.

School lunches were a new concept to me, as previously I'd always taken lunch with me. There was no cafeteria at my old school, so it was never an area of contention. Now, although I sometimes took lunch to school with me, just as often I ate at the cafeteria. The burritos were my favorite, although now I'm not sure why. They were tough and stringy, and not really very much like burritos at all.

There was no getting out of P.E. at this school, as the budget was a very different story than at my previous school. There was no orchestra, and in Band, which I took instead since it was the only option, was a disaster. There was no William Tell Overture here. They didn't have an oboe in the school, so they had to find one for me. When they did, it was plastic. I'm afraid the snob in me began then to show its ugly face, and I left band, stating that playing pep songs at basketball games was not what I considered music education. I was much more polite about it than that, of course. Really the only alternative was choir, but once I got into that with Mrs M., I loved it, and I've sung all my life as a result.

I remember science, and I'm afraid I don't remember it fondly. It seemed basic and tedious to me, probably due to the fact that my upbringing had given me much of what most kids have to go to school to learn. The boys tittered at the teacher when we did the reproductive system in biology. I just didn't have the patience for that, and I tuned out.

There was world history and American history and government, of course, and I managed to avoid both home economics and typing, somehow.

English was an experience like no other. They called it "Team English", and it was based on a rotational system. Instead of one teacher teaching you for the whole year, there were three, each with a specialty. One teacher taught the mechanics (grammar, spelling, punctuation, etc.), one taught composition and one taught literature. We moved from teacher to teacher as the year progressed. I remember some of these teachers, but never made a particular connection with any of them.

In my senior year I took "College English" which was actually a first-year university class delivered on the high school campus. It was supposed to give anyone who was college-bound a bit of a head start. I enjoyed it because it was different, and at least a little bit challenging.

Math was another story. For all the forgetting I'd done up to this point, I was about to make up for it. My math teacher was a man I was to learn to loathe. He was disrespectful and irreverent, and seemed to enjoy belittling others. I have since learned that some students actually liked him, so perhaps my new-found self-esteem was still too fragile, but I found him inapproachable, and his teaching methods abhorrent.

Mr. S., like all high school teachers, would lecture, then test. Like all math classes, the concepts were tested approximately a chapter at a time. I'd feel as though I understood the ideas when he was explaining them, and I'd do the homework and think I had things pretty much under control, but then I'd fail the test. Mr. S.'s response to this was to suggest you come to him after class or after school and "beg and grovel" – his exact phrase for it – for a better grade. The idea (in retrospect) was to explain to him what you thought you were doing on each question you got wrong, and if he believed you showed

an understanding that hadn't been apparent on paper, he'd give you some of the missed points back.

But the way it came across to my frail confidence was that I was expected to beg for a better grade. I've never liked confrontation in the first place, and I certainly didn't have the self-assurance then to ask for something I didn't feel I'd earned. If I hadn't understood something, I needed to come to understand it, not just grovel for points.

In addition, he told the class that girls stood a better chance of improving their grades if they came to him in this way, because they usually cried. It put me off him, it put me off asking for help and it put me off math for years to come. I endured his lectures for a year. I think I may have gone to him for extra help once, early in the year, but never went back. He was intimidating and cavalier, and I was frightened and overwhelmed. I think I got a D in the class, so I didn't have to re-take it, but I swore I would never do math again.

I left high school in 1981, graduating exactly half way down my class. Once again, I'd succeeded in remaining obscure by neither excelling nor failing. I worked at a burger joint until I joined the Marine Corps the following year. A mildly bad back meant that career was very short-lived, and I came home again just a year after leaving. A short stint in the local raspberry jam factory ensured I never wanted to do "menial" labor again if I didn't have to, and I headed off to California with a friend in order to escape rural life. I had \$150 in my pocket, and I was 23 years old, but I was "large and in charge".

## *College*

I can't say I exactly landed on my feet when I arrived in California in 1986, but I didn't starve, and I always had a roof over my head. I'm not always sure how I managed that, but I did. Eventually I decided I was tired of getting turned down for jobs that required a college education. I knew I was capable of doing these jobs without a degree, but my would-be employers just couldn't see how wonderful I was.

I was right, of course: I could have done any of the jobs I applied for. But that wasn't the point. Employers want to know you *can get* a degree, not just that you have one. Eventually I signed up for an English class at the local community college at the behest of a friend who was teaching it. As I was later to learn, adjunct faculty at colleges will only be given courses to teach if there are enough students to take them. Hers was called "Technical Writing", so wasn't a required course, and might not go ahead if there wasn't enough interest. My signing up helped make up the numbers, and she assured me that I could always drop the class later if I didn't want to finish it. By that time it would go ahead, as they wouldn't cancel a class once it started.

In hindsight – there is a lot of that in this memoir, as in life – I think my friend was getting me off my backside. She knew that if she told me I really should get out there and go back to school I'd probably just nod and smile, possibly even agree with her, and then do absolutely nothing about it. By making it a favor, she ensured that I wanted to do it, and once I was there, she thought I would stay.

She was right, and stay I did. I excelled, and I enjoyed the course. I'd always found English quite easy, and this was no exception, but it was a different approach to writing,

and for different reasons. I could see a useful, practical aspect. I also enjoyed the feeling that I had an “in” with the teacher, because although she asked me to call her “Ms L.” in class, I knew her socially, and felt I had something the other students didn’t. I got an A in that class, but when I look back at my work, it’s clear that she didn’t show me any favoritism. My final paper is marked with red ink in just the way I’d have marked it myself if someone handed me that report today.

The following quarter I took Psychology 101, purely because I knew that I would be required to take that at some point if I was going to get a degree of any description. I did well in that class as well, and so my career as a student began in earnest, if a little slowly.

I became enthusiastic, almost obsessed. I moved to another area, and so to another college, but continued taking the classes I knew I would need if I were eventually going to get a degree. I went through my copy of the college catalogue and created a list of absolute requirements and their prerequisites as well as the elective courses I could choose from to make up the minimum number of credits for an Associate’s degree. One of the absolutes was, of course, math.

I signed up, very reluctantly, for “Math 100”. I had as my consolation that, by all available accounts, this would be the first, last and only math class I would ever have to take in college. I’d decided I was going to teach English, motivated by Ms D., and inspired and encouraged by my college English experience, I knew I’d do well in English classes. So I’d just buckle down and get this one math class out of the way, and I’d never have to look back.

It was algebra, and it had been algebra that I’d taken with Mr. S. in high school, so I was expecting it to be torture, but it wasn’t nearly as bad as I’d thought it was going to be. First of all, it was taught by a woman, and although I’d had female math teachers in school, the fact that she was teaching college math made a big impression on me. I felt encouraged on the very first day. She was gentle in her approach, easy to understand, and not at all intimidating. I remember the first time I dared to ask a question in class. Her response, before actually addressing the question was, “I’m glad you asked.” I felt courageous and proud, and after that it slowly became easier to ask for clarification, a skill that would stand me in good stead in every class I took afterward as well.

The biggest impression this teacher made came three or four weeks into the course. She’d been explaining something, writing her thoughts on the chalkboard as she went along. Something she wrote didn’t quite make sense, although I couldn’t put my finger on what it was. Somebody else saw it too, and asked, “Shouldn’t that be a  $4x$ , instead of a  $7x$ ?”

“Oh yes, thank you,” she replied, quite calmly, correcting the error as she spoke. “I never was very good with numbers.”

You could have knocked me over with a feather. She’d made a mistake – a *teacher* – and she’d admitted it, and then, a *math* teacher, confessed to not being good with numbers!

It’s amazing how small an event can contribute to the course of another person’s life. That throwaway comment has stuck with me for twenty-two years. I remember it as if it were yesterday. It impressed upon me two things: that one could be good at math

without being good with numbers, and that teachers were not infallible, and that that was okay. It was a tiny, insignificant remark that has rippled throughout my life.

I don't remember that teacher's name now. I wish I did; I'd really like to tell her that story, and to thank her.

I worked full-time at a music store at the time, and I'd do my homework whenever it was quiet, which was quite a bit, actually. I couldn't leave the store, so I'd pack a lunch, go to my classes in the morning, then go straight to work. Sometimes I did algebra for several hours throughout the day, more because I didn't have much else to do than for any other reason. It certainly wasn't out of virtue or from any sense of needing to work hard to understand. In fact, I found most of the concepts easy and I worked ahead. We'd been given a list of all the homework we'd be expected to do over the quarter, and I just started doing it ahead of the lectures. I still went to class; I really didn't know then that I could have skipped them, and besides, I really liked the teacher. I always waited to turn in my homework when it was due, by which time I'd often forgotten half of what I'd done, but it was always returned with a perfect or near perfect score.

I mention this, not out of arrogance, nor to demonstrate how hard I worked to learn math, but to give an indication of how *little* I worked, and how *easy* it was. I'd been funneled into this class because of the score I received on the college math placement test. I didn't have the background necessary for any higher courses because I lacked the foundation and understanding I should have come away with from high school. But I didn't lack the foundation because I was bad at math; I lacked it because math was effectively made inaccessible to me. I think this is precisely why people who feel they're bad at math get this impression of themselves. It has nothing to do with their ability, but with their relationship with math during a turbulent and emotional formative time in their lives. I truly believe that anyone can learn math. Some of us may learn it differently or require different approaches, others may take a long time to grasp the more abstract concepts, but I don't believe there's anyone out there who simply *can't* do math, only those for whom access to it has been denied, and afterwards, those who won't, out of a sense of self-preservation.

I got an A in that college course, and for the first time in my life I felt as though I was actually pretty good at math. That was only the beginning though. I moved to Texas in 1990, and started at the community college closest to my new home. I took with me a continuing determination to pursue a degree; in fact it would be accurate to say that getting an education had become my full-time occupation, not only in the form of the pursuit of knowledge, but in the organization of information required to streamline and follow through on the process. I acquired a copy of the catalog for this new college, and as I had done for the previous one, made a list of all the courses I would need to take, the order I'd need to take them in and the other requirements I would have to fulfill to get an Associate of Arts and Sciences degree. I happily noted that the math requirement was a course "numbered 100 or above", which I had already satisfied, and I arrived at the college on new student registration day, aged 26, ready to begin my position as full-time student.

As I made the rounds from one department's table to the next, far more knowledgeable about the requirements than the staff at some of the stations, thanks to my obsessive study of the course catalog, I smugly noted to the woman at the math department table that I'd taken Math 100 at my previous college, and so wouldn't need to take anything here, expecting a quick signature of waiver in the box next to the math requirement.

She very kindly replied, quite used to this sort of claim from students at her table, that according to the name of the course on my transcript, “Elementary Algebra”, the credits I’d received would not satisfy the requirements of an Associate’s degree. To add insult to injury, the course I did need to take had a *further* prerequisite. I was going to have to take *two* more math classes.

I was devastated. I didn’t believe her at first, and I tried to argue that my previous college subscribed to the standard course number system just so that this kind of misunderstanding didn’t happen. She told me that I didn’t have to sign up for a math class this quarter, but that I would not be awarded a degree without meeting that core requirement along with the others. She suggested, I think to get me away from her table, that I speak to the dean of the department. I went, thinking that perhaps I could make *him* see; that I could explain to *him* that there had been a terrible mistake, and expecting that he’d waive the requirement based on the course number on my transcript.

He didn’t. What he did do was listen very carefully to my case, and when I told him that I’d sailed through my previous class, he offered me a very rare gift: the chance to choose to risk failure. I said that if I was going to take another math class, I wanted to try the one I’d at least get credit for. I asked him if I could skip the next class – the one I really should have taken – and sign up for “College Algebra”.

He agreed to let me try, and signed off on the waiver for “Intermediate Algebra”. I felt both elated and terrified. On one hand I’d won a pretty big victory against the establishment, and I felt as though I’d got away with something. On the other, I was about to sign up for a class that could be leaps and bounds above what I was ready for, and I might fail, meaning I’d have to take it again, and possibly the one I’d skipped over as well. Overall, I was pleased, although I can’t say I was happy. I was still going to have to take more math, and I’d really felt I shouldn’t have to.

I think I took American History that quarter too, and a literature class. Geology also figures prominently in my memory. But I certainly took College Algebra, and it was hard. It was so hard that I got really scared that I was going to fail again the way I had in high school. I studied for the first test like I’d never studied for anything before in my life. I don’t now remember how I did on that first test, but I worked hard all quarter, attending extra study sessions, frequenting the “Math Lab” for extra help, doing all the assigned homework and more besides, asking questions in class, and staying after the lecture to clarify things with the teacher.

That all sounds very virtuous, but I didn’t do it out of a sense of virtue; I did it because I was desperate not to have to take the class again. I also felt I had something to prove. I’d asked to skip the class below this one, and I needed to prove, to myself more than anyone else, that I hadn’t made a horrible mistake. And along the way, I began to enjoy it.

I discovered early on that quarter that although math was hard work after all, it was also immensely rewarding to discover that I could understand concepts I’d previously thought were beyond my grasp. I got a lot of help, but in the end, it was down to persistence and simply putting in the time. This was another lesson that would prove extremely useful in the rest of my academic work: that studying takes *time*. It’s not enough to sit down and read a chapter once, and expect it all to stay in your head. Understanding how something works is not the same as being able to work it yourself.

Like any other subject, doing well at math requires regular, focused practice. My College Algebra class met every day, so I had no choice, really, but to do some math every single day. That constant application is exactly what it takes to get from not knowing something to understanding it to being able to do it yourself – in other words, to *know* something; to *own* it.

I got an A in that class as well, much to my amazement. Even more amazing was the thoughts I started having around that time. As a continuing student, I was able to select the classes I wanted to take the next quarter and sign up for them before new students got access to the remaining seats. That meant deciding what classes I wanted to take, and which teachers I wanted to try and take them with. An idea started to move around in my mind like a wisp of smoke, its tendrils curling and tickling as it went. Sometimes it would tease me with what a good idea it was, and others it would warn me that it was foolish and dangerous.

In the end I decided to try it. I was going to sign up for Trigonometry. I reasoned that I could always drop the class if I felt it was getting too hard, and that I wasn't going to succeed, but that if I could pull off Algebra with the background I had, then maybe Trig wasn't too much of a stretch. Besides, if I did succeed, it would open more doors for me. Everyone knows that English teachers are a dime a dozen, but if you can do math, the world will beat down your door to offer you jobs. It's not quite that straightforward of course, but that's what my head told me when I took that leap of faith, and it turned out to be a very good decision.

## ***Transition***

My Trig teacher was Dr M. He was from Zimbabwe so he spoke with a bit of an accent, but he loved his subject and he loved teaching, and he seemed to have a permanent smile. I felt for the first that semester as though I really could do math. I'd passed the one class I had to take with flying colors and was taking another one because I *wanted* to. With the support and encouragement of a caring teacher, I began to realize that actually, I was even pretty good at math.

Don't get me wrong: Trigonometry was hard. I had at least been exposed to algebraic ideas before, so extending them to do algebra at the college level didn't seem like such a stretch, but I'd always considered Trig one of the "hard" topics. I'd never seen a sine ratio before, or heard about radians (a way of measuring circles). I was in uncharted waters, and I struggled with some of the ideas I had to learn. But I kept my head down and repeated what I'd done with the Algebra class, going to the "Math Lab" for help, seeking out Dr M. to ask questions, doing all the assigned homework, and so on.

I got a B in Trigonometry. When I learned that I hadn't received an A, I was pretty upset. I'd worked really hard, and I thought I'd done better than a B. (It will help to know that I was a pretty narky little teacher's pet type too, and gained As in most of the other classes I was taking at the time.) But in hindsight, I think it's remarkable that I did that well. I'd come from desultory results and extremely poor foundations in high school to achieving high grades in college level math classes. If that doesn't show you what an impression a teacher can make, either good or bad, I don't know what will.

By the time I finished Trig, I'd made another big decision. The plan had always been to get my Associate's degree and then transfer to a university to go for a Bachelor's degree.

I'd been taking English classes all along and found they weren't really getting any more interesting. I had good teachers; in fact I had some excellent teachers, but I'd grown up reading and writing well beyond my years (thanks again Mum), and I began to feel that if I wasn't learning anything new in my second year of college, it wasn't likely to get any better in the final two years.

Toward the end of the spring semester as I was getting ready to graduate from that college, I started to flirt with an idea that terrified and excited me at the same time. I'd turned out to be pretty good at this math stuff; maybe I should just make a go of it. I could keep taking English classes, just in case, but maybe I should try taking more math as well.

At first I shook it off. I thought I was just feeling the confidence of a single good experience. But when I got brave enough to actually mention it to Dr M., he was very pleased and encouraged me to follow that path. I vacillated for a long time. It wasn't until I was actually registering for my first quarter at the university I transferred to, while I was filling in the new student form that I took the plunge: where the form asked for my major, I wrote "Mathematics" and a new wave of excitement and dread washed over me. But I didn't change it.

## *University*

I started university during the summer, not wanting to lose any time. Having decided to go in this direction meant that I had some serious catching up to do. I had two years to take all the math classes normally taken over a four-year time frame. I didn't have an illustrious start, only gaining a C in my first math class at the university, but I still maintain that this was a big achievement for someone with my background.

This reasoning wouldn't be good for much longer, since, as I took more and more classes, I increased both in skill and in confidence. Coming from a poor start to an A in College Algebra is one thing, but now that I had that knowledge, and that from Trig and now Analytic Geometry, *this* was my foundation for the courses I would take over the next two years.

Summer courses are usually pretty quiet, and the campus under-populated. It can feel a bit like a ghost town. Fall quarter brought all the excitement of a new school year. New experiences and new friendships all still to come.

My first "real" math class at the university was to be Calculus I. The very fact that it was on my schedule made me shake my head with disbelief every time I looked at it. If you had told me even one year before this that I'd some day be taking a calculus class, I would not have believed it. But here I was at 8:45 on a Monday morning in August, waiting outside a lecture hall to do just that.

I always arrived early for new classes, since I have an overwhelming paranoia that something horrible will happen if I arrive late. This morning I was to discover that this habit would make one of the lucky few. I'd aimed to arrive 15 minutes early, thinking I could take my time and select the seat I wanted. I hadn't counted on the fact that there could be a class in even before ours, so I stood and waited outside for it to finish. By 8:50, when the other class finished, the large, open foyer where I stood was full of students. By full, I mean overflowing. Those leaving the lecture hall could hardly move

for those of us waiting to go in. And we had to wait, as there were only two doors to the room, and both were impassible as students came gushing out after their first lecture.

Once the last leaving student cleared the door where I stood, I went in, followed by what seemed like hundreds of my peers. I scanned the space quickly, taking in its cavernous size and theatre-like setting, with raked seats and a stage. I didn't have much time to make my decision, so I flew down to the front of the room and took a seat in about the third row. Before the class had started, the 350-seat theatre was full.

I was later to learn that Calculus I was what the university (or at least its students) called a "weed-out" course. The engineering department was highly touted as one of the best in the state, and it used Calculus I to "weed out" less able students. By making it difficult for engineering students to pass an early hurdle, they quickly found themselves with only the cream of the departmental crop.

But this didn't happen right away. Thousands of unsuspecting students signed up for Calculus I, which was why the university needed such big halls in which to teach the course. Just seeing the throngs was enough to get a lot of them to drop the course. Others left after the first week or two when they discovered how inaccessible the professor was and how much work was involved. The class only met three times a week for an hour, but there were also two "labs" per week, led by graduate students, where most of the actual learning took place. These only had 30 or 40 students in each section, which was much more like the scenario we were all used to. The graduate student instructors re-delivered the lecture material, answered questions and gave quizzes.

Cut-throat Calculus. I'm still amazed that I didn't bail out early on, but I had begun to develop a sense of self-challenge. I didn't know how to quit without feeling like I'd failed. That need I developed in College Algebra to prove to myself that I could do something I felt I had no business doing kept me from quitting several times in my goal to obtain a degree in mathematics. My first Calculus class was a good example of that need in action.

In fact, though, after the novelty wore off and the drop-out rate leveled out, I found it wasn't as hard as I'd been expecting. To begin with, many students came to this class, which was supposed to be a freshman course for mathematics students, with a weak background in Algebra. Either they'd been to a College that didn't have a good math department or it had been too long since they'd taken Algebra. As a result, the first thing we were assessed on was Algebra, to make sure we were all up to speed. Without strong skills in manipulative Algebra, it's very difficult to learn Calculus, as the concepts rely heavily on manipulating information algebraically.

I had no such trouble. My college, it turned out, had had an outstanding mathematics department, and I'd only just graduated the previous June, so all my Algebra was fresh in my mind. That didn't mean the exams were easy though. The class policy, established very early on, was that if you failed an exam, you could retake it for a higher grade, albeit with a cap on the possible maximum. When we got our first exams back, the fellow I happened to be sitting next to that day cringed as he looked at his grade. "What did you get?" he asked me.

"A 'B'," I replied, disappointed. The exams were in line with that weed-out policy I mentioned; in other words, they were intentionally difficult.

“Wow!” the young man said. “That’s great! How many times did you take it?”

“Just once,” I told him.

“Damn. I took this three times, and I still got a C-minus...”

But that’s what it was like. Hard. Unrelenting. Cut-throat Calculus.

I thrived in that class however, possibly in large part because of the comment my fellow student had made after the first exam. I had only managed a B when I’d been hoping for an A, but I did it in one sitting while others had made multiple passes at the elusive passing grade. I’m not saying I was smarter than the rest of them; just better prepared. As the course went on I found it harder and harder to understand the new concepts. But I always attended the lectures, arriving early by design so that I could get a good seat in the vast hall. I always went to lab, and I frequented the drop-in center for any extra help I needed. As usual, I did all the homework assigned, and if I still needed help I’d seek out the instructor or my grad student.

In the end, I never had to take an exam more than once, and I got a B in the class. Not bad for someone who had sworn off math at age 16. I also took Number Theory that term and Discrete Math the following term. I got an A in Calculus II and a B in Calculus III. I took Linear Algebra, Probability & Statistics, Differential Equations, Abstract Algebra, Real Analysis, Partial Differential Equations and more Abstract Algebra before I was through. I also took education courses.

I didn’t always succeed, at least by my standards. I have two Ds on my transcript and more than a few Cs, with an accumulated GPA of 2.9. Not award-winning stuff, and nowhere near the “with honors” I’d hoped for when I started out, but I graduated in August 1995. I wore a cap and gown and dragged my family down to make them watch me collect my degree. I don’t think they minded; I was the first one in my family to go to college, let alone university, *let alone* study math. It was a hard road at times, but I never regretted it.

### ***...And Beyond***

After teaching for a couple of years, I felt the need to move closer to my family again, and I ended up working – teaching – at *my* local college. I was part of a program that helped adults who had been displaced due to injury or illness. For eight weeks they took a half day of basic skills classes (English, math and computers) and had a half day’s coaching to improve their job-seeking skills. I taught math. Every day I marveled that I was the teacher. I’d always known I was going to teach, but I taught *math*. I still have the feedback those students gave at the end of their eight weeks, because I love to read what they thought of me as a teacher. I helped people who had given up on themselves to believe again that they were capable, intelligent and worthwhile. I taught people who believed they were “no good at math” to learn things they never thought they’d be able to do. In other words, I taught people just like me.

It wasn’t rocket science; I wasn’t teaching Calculus or anything “hard”, but it was hard for them. In the same way that I’d started with a course in remedial Algebra, and in the same way that I’d had teachers that had encouraged me, I was now doing the same for others.

I still enjoy working with this type of student, and I think I'm particularly good at it. I can convey concepts to them that they'd been unable to grasp before. It's not because I have a special talent for math; far from it. If anything I'd say my skills are comparatively weak, given the level I've managed to attain. But I know their frustration. I understand. I was *there* and I remember the feeling of worthlessness and dissolution I had when I couldn't figure something out for myself and I couldn't find someone who cared enough to explain it so that I could understand.

I do care, because I know what a difference that kind of understanding can make to your self-esteem, especially when you've believed for as long as I did that you're "just not good at math". I mean look at me. I *am* good at math! But for years I just *knew* that I wasn't.

During this time I also "taught" a course in College Algebra. The very class that began the turnaround for me. It wasn't a standard classroom lecture format but a series of videotaped lectures that the students checked out at the college library. They watched these instead of attending lectures, then took exams. But they still had questions, and somebody had to grade the exams, so they needed an "instructor of record" and that was me. I met with students when they needed extra help, and I graded their tests and reported the results to the registrar. I didn't get much student contact, but I regularly walked across campus, shaking my head in disbelief that I was even there. *I taught college math.*

I enjoyed it so much that I decided I'd really like to do it full time. To do that however, at least at the college level, you have to have a master's degree. So the cycle began again. I flirted with the idea, and it became stronger, and eventually I applied to attend graduate school. For *math*.

## ***Graduate School***

I chose the wrong time of year to embark on this particular endeavor; the academic year hadn't started yet, but it wasn't far off, and there's a lot to do to prepare for graduate school, although I didn't know it at the time. The application is one thing, but even once that's been filled in and the transcripts from your undergraduate degree forwarded to the university you've applied to, there's still the GRE (Graduate Record Exam) which has to be scheduled with an independent testing center, an interview with the department and the financial aid process to go through. Each of these takes time, and although at the time it felt like I waited forever to start, I couldn't really have started any sooner than I did, so long did it take to put all the pieces in place.

In fact, I started early anyway, as my undergraduate GPA wasn't strong, and the department head wanted me to show them I was capable of the level of work I'd be doing starting that September. They had me sign up for two undergraduate classes during the summer term. I thought it would be a cake-walk, since I already had a degree, but I was to learn that although my previous alma mater was a very good engineering school, it wasn't as strong as my new one when it came to pure math.

The classes I took that summer were challenging, but I enjoyed the fact that I could dedicate all my time to study. I had taken an apartment near the campus, and I led a life of leisure, going to classes and very little else. So little, in fact, that it wasn't long before I realized that the odd feeling I'd felt growing and increasing as the weeks

passed, was loneliness. I'd moved to a new town and put myself in a new situation where I knew nobody. I didn't have work to force me to interact with others, and I didn't know any of my classmates as well as they seemed to know each others, so I kept to myself. I'd never experienced that kind of isolation before, and it actually took me a while to figure out that's what it was. I managed to get through it, and I suspect the inordinate amount of time I had to devote to my coursework played a large part in the grades I received: an A in Number Theory and a B in Mathematical Modeling.

The summer passed, and the campus began to buzz with the anticipation of a new school year. That time of year has always been my favorite. The summer has finally "turned" and the long, lazy days begin to shorten, giving me a sense of wanting to draw in on myself. It's not a feeling of hibernation, but of new beginnings. I have an overwhelming sense of open-endedness; of wanting to take on new projects, start new ventures. To this day, between September and October I find it difficult to resist the urge to buy new pencils or sign up for a course at my local college.

As the summer term ended and fall began, I started to observe some interesting things. The relationship a graduate student has with her professors is very different from the one an undergrad has. There was camaraderie in the department that I'd been completely unaware of previously. This might have been in part because the department was bigger at my previous university, and therefore had more of a sense of anonymity, but I think it was also because my place in the pecking order was different. Here, the whole department had an easy, comfortable feel, and even the undergraduate students were afforded a certain amount of recognition that I hadn't experienced. There was still a definite hierarchy however: The department chair and his administrative staff had everyone's unwavering loyalty; the professors and instructors came just below that, then the graduate students, followed by the undergraduates majoring in pure math, and everyone else at the bottom. "Everyone else" included undergraduate students with other majors. Although non-math majors were not ignored, the fact that you were studying math – intentionally and actively pursuing it – meant you had a standing above those just taking a math class because it was a requirement. I suspect it's the same in every department at every university to a greater or lesser extent, but the idea was new to me.

Professors and instructors, for example, each had an office. The dean had an office with an administrative assistant. Grad students had offices too, but we each shared with three others. We also had classes to teach. This institution is well-known in the area for producing outstanding community college instructors. At the time, I was just extremely glad for the financial assistance that teaching afforded. Without it I could not have managed to pay my tuition.

We each taught one class and took two or three. I took Abstract Algebra and Mathematical Analysis. Now, I ask you, would you have believed I would write that sentence when you began reading this biography? I certainly wouldn't have; even now I marvel that such a transformation was possible. But that is exactly why I am writing this: I want everyone to know that you can change your own perceptions about what you're good at (or not good at). In my case it seemed to happen almost by accident, but it did happen, and if I can go from virtually math phobic to master's degree candidate, anyone can.

In the two years that followed, I took classes like "Advanced Calculus of Several Variables", "Graph Theory", "Topology", "Queuing Theory", "Probability" and

“Statistics”. I also taught everything from “Developmental” Algebra to “Math for the Non-Science Major” and Pre-Calculus. My favorite class to teach was the “Developmental” one though. I felt an affinity with the students in that class, most of whom resented having to take it. They would have been assigned from their placement test results, as they would not have succeeded in the course required for a degree. But although they had to pay the tuition for the credits they received, they would not be able to use those credits toward a degree, as the class was not at a sufficiently high level. Sound familiar?

Somehow though, I managed to get through to many of them. I started every class – and I still do – by telling the students about my humble beginnings: that my first college math class was a “remedial” class. It lets them know, I hope, that I do understand.

My two years as a master’s candidate was not without its frustrations. Two of the required courses were taught in such a way that I found them incredibly difficult to cope with. There were two issues: one was that I did not have a strong background in writing proofs, and these classes were all about proofs; the other was that the class rules stated explicitly that you could not work with anyone else on any of your proofs. You had to work in a vacuum (the instructor’s guidance, such as it was, was the only exception), and then you had to present your results to the class. I have no idea how I passed either of those classes. I did pass – just – and I had a lingering feeling about them that closely resembled the way I felt after Mr. S.’s algebra class in high school: I HATE proofs; I’ll never do another proof as long as I live!

I don’t actually feel that way now, because I’ve learned that it’s probably not me that’s the problem. It’s not that I *can’t* do proofs; only that I haven’t learned how to do them *yet*. And even at this echelon there are levels of competence. I can do some proofs, but not hard ones, just as I could do some Algebra, but not College Algebra when I started this journey.

Another stumbling block was the entrance exam for the program. All the new graduate students took this a few weeks after we started our first fall term. I think only one of us passed it at that point. We all re-took it in the spring. One or two more cleared the hurdle then. The rest of us tried again the following fall, and another handful got through.

This exam was supposed to display our ability to do undergraduate level mathematics. Those who passed the exam within the first couple of attempts had done their bachelor’s degrees at this university, so their background had prepared them for these particular skills. They knew how to think about the questions because they’d come up through a system that fostered and established those skills. The rest of us had a variety of backgrounds, and mine – well, mine was just poor, relatively speaking. I didn’t pass that exam in the entire two years in which I was supposed to have done my degree. I had one more attempt, and I still had my project to present.

During the second year, I was seeing my now husband, who is an engineer. After my fourth attempt at the entrance exam, I withdrew from one of the classes I’d planned to take that quarter, and I withdrew from my project. Between spring quarter that year and spring quarter the next year, I got married, moved to Scotland, met my new family and all of my husband’s friends.

And I studied. I read all of my undergraduate textbooks with new eyes, looking for information I hadn't been aware of when I'd used them earlier. I learned far more in that year of self-study than I had while I was actually taking the classes in question. I had copies of the exams going back for years, and I looked for patterns in the types of questions that were asked. I worked the problems over and over and over again, until I could do them in my sleep.

I was going to have to travel back to the US to enroll for one more quarter to do my project and complete my last class. I couldn't afford to fly back just to take this exam, so I arranged to take it in Edinburgh under a proctor, and it was delivered to her to be administered at a time and place the university had agreed with us both.

The week or so that followed that exam seemed like an eternity. I felt I'd answered the questions much more confidently than I had in my previous attempts, but I didn't know if it would be enough. If I failed the exam again, I would not be awarded a degree, and everything I'd worked for would be gone. If I passed, I still had the project to do. The days dragged while I imagined the worst. I tried not to get my hopes up, but I was desperate not to feel that the last two years had been a waste.

Eventually, the news came, through the proctor. I'd passed. The biggest hurdle in my mathematical career had been cleared. I was immensely relieved, and happy to be back on track, if with a year's delay.

I'm happy to report that I passed my project as well, and graduated, as I had with my bachelor's degree, in full colors, cap and gown – the works – in June 2002. I was 39 years old, but I felt like 19. I was on top of the world.

## ***Today***

Today, I still tell students about my “remedial” class. When I was in high school, and college, and university, teachers and professors were untouchable; they were, somehow, not real people. They were certainly not to be questioned. That began to change for me when I was working on my master's. But if I'd known when I was 16 that Mr. S. was just a person, I'd at least have had a chance. I'd have known it was okay to ask him for help in spite of what he felt was necessary treatment for that action. I'd have known it was okay to ask someone *else* for help if I couldn't get what I needed from my own teacher. I'd have known there was no shame in asking for help, since the very act would indicate not a lacking on my part necessarily, but a failure on the part of the establishment to provide what I needed to learn.

One of my own high school students once told me that he thought it was my job to make sure he learned what he needed to pass the class. (His exact words were “It's your job to make sure I pass.”) I disagree; it was my job to make it as easy as possible for him to learn, which is subtly but distinctly different. It's not up to the school or the teacher to drag an unwilling student past the finish line; in fact it's not *possible* to teach a student who won't make an effort to learn. Education is still a privilege in my eyes, rather than a right. We cannot force someone to listen when we lecture or to study, but it is our duty to meet the student half way; to bring the information they need to a level at which they can grasp it.

I was not a lazy student whose teachers were accessible, but a frightened student whose teachers – one in particular – put up additional road blocks to learning. I was never a star pupil in school, and I was made even less willing to try by a system that only supported you if you were either excelling or failing. Or if you were on the football team.

So when I teach, I try always to convey that I come from very humble mathematical beginnings myself; that I am a real person, that I am accessible, and that I want the student to understand and will make every reasonable effort to ensure that happens, if only they will give me an indication that they want that understanding for themselves as much as I want it for them. It seems to be a good approach. I've had students tell me "You're the only person who's ever been able to explain this stuff so that I can understand it," and "You make it so easy – why doesn't my math teacher explain it that way?"

The answer to that last question is more complicated than you might think: your math teacher may or may not be a "good" teacher, but a classroom teacher has demands on their time and constraints on their techniques that students are largely unaware of. There's a mountain of material to cover in a fixed amount of time, and 30 people to deliver it to. When you're working one-on-one with someone, you can take the time to find out what their particular learning style is, and where the gaps are in their knowledge. You can read their facial expressions as you explain and adjust the explanation to match their ability to take on information. A classroom teacher can make those concessions during a tutoring session – before or after school, for example – but heaven help her if all of her students demand that kind of help. 30 students across six or seven classes is about 200 students every week, and even an hour a week for each of them is simply out of the question.

The vast majority of students will not ask for extra help, and if they do, it's likely to be on a one-time basis. Those who go to their teacher for extra tuition regularly will likely get the help they need, and if not, I hope they seek out extra help from other teachers. I know if a student ever came to me and said "I don't understand Mr. Smith's explanation of polynomials, and I'm scared to ask him to explain it again," I would happily offer a fresh set of eyes and a new, perhaps different way of approaching the problem. It wouldn't matter to me if I'd ever seen this student before in my life; it's in my nature to help those who ask for it, particularly when it comes to math, and I take it as a big compliment on my ability to convey information that others don't always manage to get across, when I'm asked for help by someone who is not normally under my instruction. So this hurdle is easily cleared simply by asking. But anyone with low self-confidence or misconceptions about not being "allowed" to seek extra help won't ask, and that can be a death-blow.

It should also be said that it's not always – in fact it's not usually – that Mr. Smith is a "bad" teacher that drives students to ask for help from someone else. We all take in information in different ways. I have great difficulty understanding a new idea if I can't see it written down. I even (still) really struggle to do even fairly simple arithmetic in my head. Write it on a scrap of paper or a chalkboard and I'm all over it, but please don't ask me to do it in my head. I can't remember the result of the first step long enough to apply it to the second step. Writing it down serves as my memory, and allows me to finish the process. In some circles that would be considered a disability. My memory is insufficient to carry out the task. Had I gone to high school in the UK I would have failed all the "mental maths" segments that students there are required to pass, even though I have shown I am quite capable of doing very difficult mathematics.

So I am a visual learner. Others are auditory learners – they need to hear the information before it really sinks in. Kinesthetic learners need a tactile connection with the information before they fully understand it. And just as there are visual and auditory learners, there are visual and auditory teachers. I'm a visual learner, so I'm also a visual teacher. If I have an auditory learner in my classroom, I will encourage them to seek help from another teacher, knowing that that is likely the only way they will fully receive the information they need to succeed. If I've helped someone who is not my student, it's likely simply because my teaching style matches their learning style; Mr. Smith is more likely to be an auditory or kinesthetic teacher than a "bad" one. And he's quite likely helped some of my students with things they don't understand from my explanations.

Are there bad teachers out there? Of course there are. Just as there are bad plumbers and bad hairdressers. But the majority of teachers really want you to learn, want to help you to learn, and the really good ones will not take offense at how you go about doing that. You just have to ask.

There are a lot of possible approaches to taking control and responsibility for your own learning, and that's what the rest of this book is about. The main thing to know at this point is that no matter who you are or where you live, no matter what your background is or what your previous experiences, you *can* do math.

Trust me, I've been there...