Chapter 4

Math and Me...

...it's getting personal

If I'm completely honest, I've somewhat dreaded writing this chapter. I love math, I really really do, as I am sure you've noticed by now. However, to answer the question *why* I love math, I had to access some more quiet, sadder parts within me. You see, to me, math is personal. And, as such, telling you about my relationship with math requires me to share something close to my heart. It requires me to open up and be vulnerable, and that's scary! But I know it will be *essential* — because my aim in this chapter is to convince you that math is not just numbers and calculations, not even just intriguing riddles and clever games, but something that can touch a person's soul and change their life for the better. So let's start!

You probably know what it feels like to be misunderstood. You might even know what it's like to entertain a conversation where, no matter what you say, it's like the two of you speak a different language entirely. It becomes unimportant whether the other person intentionally tried to dominate the conversation by twisting your words, or whether they honestly misunderstood and now operate from the standpoint of their perceived truth. The pain of not being seen and not being heard is real. And, depending on how hostile the conversation environment is, this pain might be accompanied by a panic that causes you to frantically look for the exact right words in the situation. You might start to wonder: Will the discussion escalate? Will the damage

done to the relationship be irreparable?

If you have ever experienced what I described in the paragraph above, then you will know how horrible it feels to be in this situation. It feels demoralizing, helpless, powerless. You may even give up on the conversation — maybe even the *person* — altogether and resign yourself to a state of defeat.

I've had too many such conversations in my life. I can only guess why this keeps happening, and I've made adjustments accordingly: I make an effort to communicate more clearly, I've learned more nuanced words, I may even try to mimic the communication style I observe the other person using, and I do my best to clear up the viewpoints and assumptions from which I operate beforehand. And things have improved, for sure. By now, I have been fortunate enough to build lasting relationships with people with whom reaching a mutual state of understanding feels almost effortless. However, these relationships do remain rare. As a whole, I live in a world where I have to put in an immense effort to be understood.

With one notable exception: the world of math. Even with other mathematicians I have the occasional misunderstanding, but these are usually of language nature — clearing up nomenclature and vocabulary — but not a matter of principle. Among mathematicians, I experience a shared set of values, which is, undoubtedly, inspired by math. And this circumstance furnishes a deeper understanding from the get-go.

As math is all about proving premises, my goal for this chapter is to do that very thing. I aim to exemplify, using myself as proof of example, that math can be more than a tool. I am sure every one of you, valued readers, has felt at some time or other that sense of being isolated, misunderstood, and disconnected. For some of us, math can be a balm for these ailments of the soul, a bridge that brings us together. It can be a lifeline, a passion, a community, a home.

4.1 Learning to belong

Let me backtrack a little bit: ever since I was a kid, I have felt like the odd one out. Well, I was quite overweight and I was a nerd, so really no surprise there. But to me, it never felt like those two attributes were the actual reason for being different; it felt like there was something else, something I could not quite put my finger on. Even among my friends, I was met with a quizzical and sometimes judgmental stare if I spoke about the things that *really* entertained my mind. I didn't understand why. After all, the things that interested me where not violent or malicious or cruel. What I wanted to talk about were ideas, concepts, patterns. I wanted to understand deeply, and the fact that my peers seemed to think this desire weird made their disdain personal. It made me feel alienated.

One day, and I don't exactly remember how it came to this, I attended a Math Olympiad prep class. Given the premise of this book, you're likely thinking, "Hurray, the mother ship called her home," right? Well, not quite: I attended the first class, and boy, did I *not* fit! All the other kids were already brilliant mathematicians, they lived and breathed logic, they could recite theorems in their sleep, and they spotted creative ways of solving particular Olympiad problems from miles away — at least, that's how it appeared to me. I was none of these things. Yes, I had a good sense of math, I showed the right attitude by wanting to understand principles and patterns rather than learning formulae by heart, but I was not *that*, whatever the other kids were. But even though I was once again not part of the group, something kept me there. I was still different, but *different* different.

Even though I couldn't articulate it at the time, what kept me there was a shared sense of math, and the set of values and principles it informs. Don't get me wrong. Throughout the entire time I was in Math Olympiad, I was actually really bad at it. I never performed well in the actual competition, and even during practice I lagged behind the others. But none of this mattered to me. The people there had the same way of thinking I did; they had just already learned to voice their thoughts in

this language I was only beginning to learn. I knew the whole time I was there that the concepts spoken about, the techniques and methods we learned, and this new way of thinking we were exposed to all *belonged* to me — only not just *yet*. I would have to learn to get there, learn in order to belong.

4.2 A shift in my mind

However, life decided to take a detour: after graduating from high school, I took quite a break from math. I took a break from my usual life, really. I had just turned 18 when I decided to see the world and move to South Africa to do some volunteer work in a children's home and a seabird hospital. And what do you know? Moving from a quaint village in rural Austria to the buzzing metropolis of Cape Town felt like giving sugar to a child: I wanted *more*. I *needed* to keep exploring and to revel in this newfound freedom away from everything that was familiar. So, after just a few months, I decided to stay. I enrolled in the University of Cape Town.

Seeing that I had no idea what I wanted to do with my degree later in life, I deemed it a good idea to study music, classical composition to be exact, because I had always enjoyed music and I do view myself as a creative soul.

However, only about a semester in, my studies became less joyful and more and more tedious. I spent very little time on composing new pieces and exploring different techniques to do so — that was part of it, but too minor a part for my liking — and seemingly endless hours practicing piano, to the point where I no longer enjoyed playing my instrument at all. I began to associate playing the piano with anxiety, frustration, and anger. In short, I found that I liked the *idea* of being a musician but not the actual lifestyle.

So, after just one year, I changed my major to math. I will spare you the details of how it came to this. Suffice it to say that I had already taken a class called *Math for Biologists* to fulfill my music curriculum, and a conversation with my parents gave me the final push. (If you skipped the Introduction and are

curious about this conversation, you can read about it there.) And it didn't take long after walking into my first math class that I knew I had arrived.

Still, especially my early journey was not without its hiccups. By the time I started studying math, with all the gaps in my learning and other hiatuses, it had already been almost three years since I finished high school, and there were a lot of things I just didn't remember. Furthermore, I attended high school in Austria, so all the nomenclature I had learned was in German, and now I had to "math" in English. I remember an incident in which I asked an instructor during an exam what "perpendicular" meant. From his facial expression, I inferred that he thought I had not practiced and therefore didn't know the concept. But he didn't realize this was a *language* issue, not a fundamentals issue. For, up until that point, I had only been exposed to the word "normal" to indicate that two lines intersected at a 90° angle. He eventually did tell me (I guess my accent gave me away), and it all worked out.

On another occasion not even halfway through the first semester of my new major, we had been talking about polynomial division in class, and the professor insinuated that we should remember this from school and that he, therefore, wouldn't go into detail. Whether in my high school polynomial division was never covered, or whether I had just completely forgotten how to do it, I cannot say for sure. I knew only that I was lost. So, after class, I went to the professor's office, and I told him my calamity and begged for a way to find out how to do polynomial division. He refused to give me a resource, explaining it was "too close to the test" and I "wouldn't be able to learn it in time, so don't bother."

Oh, boy. This set off a fire in me. "You think I can't learn this in time for the test?" I thought, proverbial fists clenching. "You're underestimating me!" Not only that, by refusing to help me, he was intentionally setting me up for failure!

Not just to prove him wrong, but to prove myself capable, I *did* learn polynomial division in time — in general, one should learn for life, not just to ace tests or to spite one's highbrow professor, but hey, I'm only human — and if I may say so myself,

I performed flawlessly.

Toward the end of my first semester, there was a placement test that would decide whether I could stay in the accelerated course or whether I had to change to the extended program that would move through the material at a slower pace and thus take a year longer to complete. A test score of more than 50% meant I could stay; less than that meant I had to change programs.

Well, I got 48%. So close! Deep down I knew that it was just a matter of time. Given another month or two in the accelerated program, I knew I could turn everything around and become a top student. One might say I had a healthy sense of intellectual arrogance at the time. But really, it was that math was becoming mine, as I knew it would back in my Math Olympiad days. Have you ever stepped into something that just clicked for you? That filled you up and gave as much as it took, so you were never depleted? Something that was *yours*? I just knew I could do it. At this point in my life, the math way of thinking felt so close I could smell it!

I pleaded to stay in the accelerated program. Unsurprisingly, it was strongly suggested that I change course: if I was this close to failure this late in the semester, I was not cut out for the accelerated program, the professor implied. Eventually, they relented. I was allowed to stay. I remember a "suit yourself, you'll see where that takes you" attitude in the air. They didn't believe in me, but I did.

And I was right! Not even a full month later, everything I wasn't able to do at the time of the test clicked into place. My thought process had shifted; I was now able to *think like a mathematician*. It may have taken years to get there, much longer than many of those kids in Math Olympiad from my high school years, but this was my pivotal moment. From that time onward, I was able to distill concepts to their essence and visualize them. I was able to "abstractify" as needed and look at problems from different viewpoints. Since that moment, I *am* a mathematician.

And it showed: I was now a straight-A student. My overall grade for my first year of math was 81% despite having a rough start, and I never got a grade lower than 80% in math for my en-

tire university career. Of course, thinking like a mathematician entails much more than "good grades" in your undergraduate studies, and I would continue to do a PhD, several postdoctoral fellowships,[1] and publish a number of research papers. But grades are much easier to quantify than the quality of research.

One could argue that the doubt of my professor and other people in my class motivated me to go the extra mile to learn math, practicing endless hours and diligently going through the examples. Or that the fact that my parents had to pay quite a lot of money to make studying in South Africa even possible prodded me with guilt and duty to finish my studies in the minimum time possible. And while both of these things are certainly true, and the extra amount of time I put into doing the work after class is what ultimately formed new neural synapses that made me think like a mathematician, it was neither pride nor guilt that propelled me through my studies. What kept me going was that deep down, I knew I had found what I was looking for. All these years, I was searching for something that would give my heart joy, a place where I could understand and be understood, a place where I belonged. I could always imagine this place, but in the real world, it remained unclear, hidden behind grand copper doors. But now I had found the key: the doors swung wide open, and I was stepping fully into the wonderful world of math!

And to you, dear reader, I want to say this: just because you thought you weren't good at math, or that you "couldn't get it" in school, doesn't mean that needs to be true for you forever! It took me years to get there myself, but the journey was more than worth it!