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Nathalie M. Luna

*University of Texas Rio Grande Valley*

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# Surviving Mathematics

Nathalie M. Luna

*University of Texas Rio Grande Valley, USA*  
nat.luna.64@gmail.com

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## Synopsis

In this essay written in an informal voice, the author shares the ups and downs of her experience in academia. She shares her motivation to study mathematics, her undergraduate experience in Puerto Rico, and her graduate experience in South Texas.

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I used to play a game that started with a little voice in my head saying that I deserve none of the academic accomplishments listed on my résumé. *That job title sounds way more important than it really was... I was the member of this other research project who contributed the least. My name should not even be on that paper... I'm sure the work I did on this fellowship, was mediocre at best. People must think I did something extraordinary... Really, I was part of this other program by chance. Nothing more...* The rest of the game consists in riding the train of thought that follows. It flows as easy as a woven fabric comes apart after a small corner is undone. Whenever I mention that I studied mathematics, I always get similar responses.

“Oh, I could never do that.”

“Wow, you must be really smart!”

“I love math, but I don't really understand it.”

I don't always let them know that the subject intimidates me too; paralyzes me at times. I don't tell them everything the little voice is screaming at me to say. I don't admit to them that the subject has at times made me feel like a monkey admitted to university as part of a social experiment. Mathematics and I have had a long relationship but it was not always so unnerving.

I was born in the south of Puerto Rico, to parents who never failed to encourage me. They supported me and my siblings in both our artistic and our academic endeavors. They enrolled me in a ballet company, where I later became a soloist. And they enrolled me in a private Catholic school, where they hoped I would receive a good education. It was there, when I was 16 years old, that I first saw a pseudo-formal mathematical proof.

In my 10th grade geometry class, Mr. M showed us how to apply the SSS (side-side-side) theorem to show that two triangles were congruent. The three conditions from the hypothesis were satisfied and encased in neat boxes on the chalkboard. A white chalk arrow drawn by my teacher pointed to the conclusion of the theorem. That was what Mr. M had proven in that small classroom packed with adolescents. I still remember how I looked at it and how it suddenly clicked. It was the truth. It made sense. Then, he asked us to do the same steps on a new set of triangles using the SAS (side-angle-side) theorem. And I did! I looked around at my classmates, wondering why they didn't seem as excited as I was. We had just learned how to indisputably prove something. What an amazing feeling, unlike in any other class! I knew my textbooks from other sciences must be telling the truth, but the subjects seemed so far away from the classroom that they might as well have been a fiction novel to me. When it came to math, I saw it live and in front of me, and that made it seem more real. What was more, I felt that with enough time, I could discover and prove for myself what the textbooks said. That made me feel capable.

So that was the beginning, when mathematics presented itself to me as a concrete wall so immense that each and every law of nature (along with its detailed explanation) fit on it. Each word, each letter, had a reason to be there. The wall's foundation made it effectively immovable but its ends escaped beyond the horizon. In the relatively small portion of the wall that was visible to me, the unknown author explained what I had already studied. To see a more complete section of the wall, I would have to perfectly understand every detail of all that was visible to me at the moment. Only then could I take a step back to see a bigger picture, the same way that, in a museum, a student studies each brushstroke of a painting and then moves farther away to appreciate the complete image. After that high school geometry course, I decided I would study this wall and its infinite complexities.

Because I like to make things harder for myself (or so I have been told), I applied to a university that is considered one of the most demanding on the island. I had heard that this university, which will remain nameless here, specialized in engineering and had a very strong mathematics program. After being accepted, I traveled to the west coast of Puerto Rico to earn my bachelor's degree. Studying mathematics at University Nameless was like running as fast as I could toward the wall in an attempt to (one) cross through it, and (two) collect all that is written on it, using my brain as a net. After rediscovering what solid-state matter is, I would get up from the floor and try again. During this long and tedious process (which I have seen last anywhere from four to ten years in this institution) I was not alone. The professors, for example, were a constant that I can now use to measure and describe my undergraduate years.

Most of them would only look with sad eyes at my fruitless efforts to cross the wall. Then, they would award me with a well-deserved F. It was obvious that I had not learned the lesson; I was still on this side of the wall. This happened in most of my concentration courses: linear algebra, abstract algebra, two out of three calculus courses, ordinary differential equations (ODEs), partial differential equations (PDEs) . . . The first time I took a course, everything seemed intuitive enough to understand, yet I felt like I missed the intricate details that explain why everything is as logical as it seemed. After taking it a second time, I learned through repetition and passed with a C. Grades like this were alarming to a person who had maintained a 4.0 average throughout high school. But in this bizarre University Nameless, it seemed to be the norm. Half the students in each class would drop the class halfway through the semester. Another percentage (of which I was part) would stick around until the end to receive the inevitable F while attempting to learn something to use the next time we took the course. I waited for a long time for someone (a good-natured professor, a smarter student than I was, some celestial voice, please!) to tell me what I was doing wrong and how to fix it. I later learned that the secret to success is not actually a secret.

The professors who did have something to say were not helpful to me. Many times I found myself on the floor (broken nose, courtesy of my favorite wall), and this vocal type of professor would tell me he had no idea how I could not manage to duplicate what he was doing. The instance I remember best was the first time I took a real analysis course. It was the first and last course I took with Dr. C.

After the first test, Dr. C gave us a piece of advice which, although dry, came from the very bottom of his heart. “If any of you feel like you’re struggling with this material, please, ask yourselves if you should be studying math. Consider changing majors.”

He was not mocking us poor idiots who hadn’t passed the test; and he wasn’t joking. Dr. C is a man as serious as he is brilliant. Even though I did not find his reaction particularly helpful, I involuntarily followed his advice. How can I not believe this professor who tells me I should not be studying math (the little voice in me asks) when there is ample evidence that he’s right? If the subject was as easy as he said it is, and I’d failed in this spectacular way, I had to (inevitably!) reach the conclusion that I was incompetent at mathematics. But even though my grades did not improve at all that semester, I did not change majors. As for the real analysis course, three out of 30 students passed it.

I met other professors, however, who went to the trouble of seeing things from the students’ perspective. These great and rare professors would lend a helping hand after some of my many collisions with the great wall. Once I was back on my feet, they would send me with much sympathy to repeat the operation from ten more feet away.

I was lucky to have a professor like this as my mentor during my first research project. It was rumored that Dr. O was so dedicated to mathematics that not even hunger could break his concentration on his studies. During his youth, he had had some health issues due to lack of proper nutrition and excess of work. It was his philosophy that mathematics requires much self-sacrifice. That is what he tried to teach in his courses and in the many undergraduate research projects that he led.

With Dr. O, I studied the theory of modular factorization. He guided me through the research and sent me off to conferences all around the island, and then to Seattle, Washington—my first time outside Puerto Rico. When we had worked together for a while, he suggested that I apply to summer programs, where I could learn things I normally would not in a classroom. That was how I got the opportunity to visit Ohio State University and the University of New Mexico. That was also how I came to participate in an Undergraduate Research Program that produced a publication and a poster at a Joint Mathematics Meeting.

While I was at University Nameless, I worked with Dr. O on a familiar concept (the greatest common factor between two integers), but with a twist: we only considered the modular factorizations of each integer. This led to some interesting, and a few uninteresting, generalizations. I would meet with him in his office, a safe zone, to discuss everything related to research, academic plans, and even personal issues at times. He often welcomed me into his office with the same question:

“Did you already change your major to dance, or are you still in math?”

It was a sort of an inside joke that began after I let him know that I'm passionate about dancing. Or at least, I always hoped it was a joke. However, as my graduation drew nearer (slowly but surely!), we had more serious discussions. After having had such a positive experience in math research, I was able to say I liked every part of the process: from the scribbles and computations on paper to the beamer presentations. I inquired about the means to work in research, and he said it was necessary to continue into graduate studies. He also explained to me, with a sad smile, that I should not bother to apply to a graduate program outside Puerto Rico, and that I was not a good enough student to be offered work as a mathematician. (What? No one wants a C average student?) He gave me the option to apply to the same institution but emphasized that it was still a long shot. Not to mention that he had his doubts about my ability to perform well in graduate courses and on exams.

Remembering him is enough to encourage the little voice. Sometimes, the invisible interlocutor asks if maybe my parents knew and hid from me that I had some learning disability. That would explain the unconditional support I received from them. Despite my academic performance, they continued to say “Go ahead, I know you can do it.” That would also explain my experience at University Nameless... *That would mean the professors are also in the loop... Is that why they try to dissuade me from studying math? Is that their way to let me down easy... ? How many more people are in on this... ?*

Little voice, please, you are being paranoid.

Several times (more than I would like to admit) I left the math building feeling sad because my mentor, whom I trusted, had confessed that my academic and professional prospects were bleak. In fact, I often wondered why he had

bothered to encourage a student he thought was mediocre to be so involved in his research. I felt confused at times. I felt angry at times. Why did he go through all that trouble if, in the end, he was going to suggest I give up on math?

In the end, I'm not sure who was more helpful: the professor who asked me with sincere disdain what I was doing in math, or the friendly one who told me with velvet words that I don't make the grade. Some people say that University Nameless is the best at preparing mathematics students. In my experience, the work I did as I crawled toward having my courses approved did not yield academic knowledge. It only made me aware that grades don't always reflect a student's work. My experience at this university did teach me, however, that we need great (great!) determination to fight for what we want to accomplish.

I earned my diploma in 2016 and felt exhausted but proud. However, every time I would look at my résumé, with its research projects, list of conferences, and publication, the little voice spoke clearly: *None of this is your success*. Part of me was sure that I did not deserve it because it was incongruous with my grades and my academic experience. That was the same part of me that agreed with Dr. O.

All the same, I sent copies of the résumé to companies that were searching for mathematicians. The résumés included all those accomplishments that the little voice disparaged and urged me to erase. The replies I received were proof (neither solicited nor needed) that my mentor was not lying to me. Therefore, I set out to use my degree to tend bar. The mixology seminars distracted me from half-formed thoughts that suggested I was settling for too little and that I had given up before trying hard enough. Except for these feelings that surfaced every so often, I liked the tasks of learning about different liquors, ways to mix them, and the correct ways to present them.

During these months, an acquaintance named C contacted me about an opportunity. I had met C at a conference in Alabama the previous year and had not seen him since. C was now pursuing his master's degree in mathematics in South Texas in an institution that we will call University of the Texan Valley. He suggested I apply to his program. I had nothing to lose. I submitted the appropriate paperwork. I was accepted (much to my surprise). So, I packed my stuff up and said goodbye to my island.

The (horror) stories I had heard at University Nameless about graduate studies formed a sinister vision in my mind of what awaited me in South Texas. However, the University of the Texan Valley was far from what I expected. And from what I heard, neither was I what the people at the department expected. A professor that helped me through the application process let slip a comment that suggested he had very low expectations for my performance in his course. This was the impression my transcript left. I didn't tell him that I was just as surprised at my performance as he was.

The courses in this institution were not easy and the workload was not light, but the professors were helpful and understanding. For example, Dr. Y and I worked on PDEs, a subject I never felt was my best. Because he is an expert in the field, I expected his attitude to be similar to what I had seen at University Nameless, but dialed all the way up to 11. I was surprised to discover that this was not the case. Dr. Y, who later became my thesis advisor, talked to me the way he would talk to a colleague. And he spoke to me patiently even when I knew I was asking too many questions.

With Dr. Y, I felt comfortable enough to ask about everything that was not 100-percent clear. Sometimes it turned out to be something I should have known from undergraduate calculus and had forgotten. Sometimes Dr. Y would say that the material was complex and we didn't have the time to go into it. Then he'd explain just the parts pertinent to our research. I asked so much that I would sometimes be embarrassed. I don't remember how I let him know about that feeling but I do remember his response.

"Don't worry. You are in this program to learn. And that is what you are doing now."

Suddenly, the terror that I had always felt about making a mistake when talking about mathematics with Dr. O seemed absurd. I had become convinced that I needed to talk like an expert and that my logic must always be flawless. I had set up ridiculous expectations of myself and never realized it until Dr. Y pointed it out. I was there to learn. If it was so obvious that I should have gotten it right away, there would be no point in doing this research. If I had known everything before starting the research, my thesis would have been pointless.

Did I get lucky to have a mentor that would open my eyes like that? Or was this experience due only to the cultural change? More investigation is needed.



What is certain is that his views on academia are an intellectual contagion that needs to happen. I already saw the beginning of this contagion when I had the opportunity to do research with another one of his students: Dr. H, who is now a professor at Yamaguchi University. I visited this institution thanks to a fellowship awarded by the Japan Society for the Promotion of Science. During the two months we worked together, we would meet twice a week and discuss some ideas about the Klein-Gordon equation. Many times (or at least it felt like many) he already saw the bigger picture and helped me get to where he was. He had infinite patience with me while I wrote on the chalkboard until I convinced myself of what he had already concluded. This soft patience created the space I needed to learn, not just the facts discovered, but also the mental tools for research.

I am grateful to the University of the Texan Valley because it reminded me how much I love doing mathematics. I discovered here that studying math can be about stepping away from the great concrete wall to admire it, and not about running into it. I also learned here that we do not need to be born geniuses to be able to study mathematics, solve its problems, or have our work recognized. I learned that the only things we need are time, determination, and an encouraging teacher.

Finally, completing this graduate program taught me that I am capable, despite the advice I had previously received. I used to incite the hateful little voice out of boredom. At other times I was busy sorting through other motivations for my low mood, and the invisible interlocutor would take that as an invitation to begin her monologue. But in those times, I did not want to hear her and conflict ensued. The last time this happened, I asked myself if the little voice speaks the absolute truth, as I had always assumed. After some reflection, I wrote an article titled "Surviving Mathematics." Lately, the little voice has been surprisingly quiet.