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Cover Page Footnote

The author acknowledges with appreciation the prompting, support and encouragement she received from her colleagues, to write this article.

The Professional Journey of a Female Mathematician: From India to the United States

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Synopsis

This article chronicles the journey of an immigrant female mathematician in the United States. The chronicle encompasses early training, encouragements received, road-blocks encountered and the background while growing up which shaped the core of her being. The loving, supportive and educative background she received early in life provided the strength to withstand the hurdles thrown in the path of her career advancement. These hurdles are not unique to the author; many immigrant professionals face similar situations. The purpose of the article is to bring awareness to these challenges such professionals face and how they still persevere with discipline and focus.

A young girl from a village in Kerala, a southern state of India, had a dream to follow in her father's footsteps, a man who embodied wisdom and greatness; a genuine teacher who left a lasting legacy of true learning. She grew up watching her father discussing literature with many of his friends and colleagues who often came to see this renowned educator and poet. Her father encouraged her to study whichever subject she chose, but once she chose, she had to do it well. He was confident in her abilities. Later in his life, he often remarked that before he left this world, he would like to see that his youngest child also got her doctorate (her older brothers were already doctors, by then). Of course, that girl wanted her father to be proud of her. She grew up to become an educator and a mathematics researcher.

I was that young girl.

My family, my roots

I am the youngest member of a family where scholarship was the norm and lively discussions were common. To grow up with a rich cultural background where the freedom to express oneself is encouraged and also to work in a society where individual freedom is treasured, one has to be lucky. I most certainly am.

Throughout my life, I was extremely fortunate to have had exceptional role models. My father was a renowned educator and a well-known literary figure, a poet of classic style. He was also a Sanskrit scholar. As a young girl, I listened intently when my father and my eldest sister discussed some characters in classic historic novels and when he explained different aspects of Malayalam (our state language) literature to my older sisters. My eldest brother was an expert in international law with a focus on human rights. His articles were cited numerous in cases, including those in the United Nations. My other brother is a world-renowned scientist. His works contributed immensely towards the improvement of world health.¹ I am very proud of them.

I grew up in an atmosphere of creative energy. At home, the tone with which my father recited poetry hung in the air. Even when I was very young, he would explain to us what he wrote and would listen carefully if any of us had any critical comments. Even though our family was not financially well-off, we considered ourselves very lucky. My father often said that he would not bother to acquire material wealth, but he would sacrifice everything to provide us the wealth of education, which no one could take away from us. Our parents made sure that they did exactly that. My mother died when I was eight years old. I have heard about numerous situations illustrating her courage, standing up for what was right and being there where someone

¹ The acquired immunodeficiency syndrome (AIDS), as we all know, was one of the epidemics of the 1980s, ravaging the healthcare systems of the world. The world was fearful of this formidable epidemic. My brother's group's break-through research identified the cause of AIDS as a virus, now known as HIV. This discovery of the HIV and the subsequent development of a blood test, by the same team, to identify HIV virus in blood supply immensely contributed to the advancement of world health. The blood test provided a safeguard for the blood supply and took away the fear of contacting the HIV virus through blood transfusion. All these contributed to the improvement of public health. I remember how he used to work long hours each day and how often he travelled all over the world during that period to share his team's findings.

needed help. After my mother's passing, the role of motherly responsibilities fell on the shoulders of our eldest sister. Even a month before my sister passed away (in 2019), we would discuss poetry, over the phone. During our conversations, she would listen carefully what I wrote. My sisters are generally the first ones to listen to my poetic creations.

From Kerala Through Delhi Towards Washington D.C.

I also consider myself fortunate to have had excellent and dedicated teachers throughout my education. I began my study of mathematics at a well-known college in Alwaye, Kerala: the Union Christian College (UCC). My journey as a mathematics educator was possible only because of the early training I received from my teachers at UCC. Among my teachers there, two were my teachers for all seven years (two years for the Pre-Degree Course (PDC), three years for the B.Sc. and two years for the M.Sc.): Professor M. Madhavankutty (MM) and Professor N. S. Neelakantan (NSN). MM's ability to control a rambunctious class, with a smile on his face, without ever being agitated, was phenomenal. NSN's meticulous description of the details of problems made them easy to comprehend. Both have left their mark on me.

After completing my M.Sc. in Mathematics at UCC with topology and statistics as my special paper topics, I arrived at Delhi University for my doctoral studies. My study for the Ph.D. dissertation included several areas of general topology, and it was done under the guidance of Dr. Shashi Prabha Arya, a brilliant topologist and a Rhodes Scholar. When the head of the mathematics department in Delhi University directed me to her, he told me that this young topologist had just returned from Oxford University.

Working through different topics in topology, I studied several papers by different experts in the field. During that period, I read several articles by Professor James E. Joseph of Howard University, Washington, D.C. Those papers were available to me since most of them were published in the *Proceedings of American Mathematical Society* and other similar prestigious journals. Reading his papers made me wonder how he came up with those particular arguments—arguments I did not fully understand. Professor Joseph's ways of expressing his ideas were so fluent that they gave insights for arguments in different settings. Engaging so deeply with his work left an impression on me.

My Howard Years

My journey as a mathematics educator in the United States started in 1984, soon after I received my Ph.D. degree from Delhi University. My two brothers and one of my sisters were already living in the United States, and I decided to join them.²

When I arrived in the United States, one of my first decisions was to get in touch with Professor Joseph. When I contacted him, he was very generous to find time to meet with me. My brother-in-law, who was completing his degree in law from Howard University, took me to meet Professor Joseph, who introduced me to his professor, Dr. George Butcher, and the chairman of the mathematics department, Dr. James Donaldson. In that first meeting, Professor Joseph and I discussed my work and several related topics. He showed interest in my work and gave me several preprints/reprints of his articles. We started working together at that time, and we continued to work together until his passing on December 8, 2022.

Even though I had offers for faculty positions from other universities in the United States, my decision to join the Howard University mathematics department was mainly due to my wish to work with Professor Joseph and to learn from him about topics of great interest to me. Moreover, the fact that one of my brothers and my sister were in Northern Virginia was an added incentive to remain in the Washington D.C. area. My professional journey as a research mathematician and mathematics educator in the U.S. started there.

At Howard, I shared my office with Professor Joseph and another brilliant mathematician, Professor Myung H. Kwack. This provided opportunities for me to listen and observe how a problem can be approached in several different ways. Professor Joseph's analytical approach and Professor Kwack's geometric interpretation of the same problem provided more clarity and insight. Other faculty members often stopped by to join in on the many discussions, especially Professor Butcher, who would immediately look at the blackboard and comment that good mathematics was going on there.

² I wrote a lot more about my experiences in the United States in an article titled "Challenges and rewards facing foreign born female mathematicians in the U.S.," which will appear in the *Notices of the American Mathematical Society* in March 2024. Readers may find some overlap between these two articles.

Ours was an office that was also busy with students. I learned during that time how to be compassionate with students' problems without compromising their academic training. This was very important for me since I came from a different educational system, where interaction between professors and students, outside the classroom setting, was limited. So, I made it a point to learn the university educational system here in the U.S. and to master as many aspects of mathematics as much as I could. Professor Joseph would give long lectures for graduate students on analysis and topology during the summer, though he was not scheduled to teach during the summer. During the summer of 1985, I attended most of his lectures on analysis; those lecture notes are invaluable source of references. I also noticed that the long lectures of my professors in India and those of Professor Joseph were very similar. I remember how Dr. S. P. Arya and Dr. J.K. Kohli, at Delhi University, would lecture for hours, without any notes. It was the same with Professor Joseph. The levels of competency and expertise as demonstrated by these master lecturers and teachers were inspirational. I try every day to emulate them.

After my first year at Howard, Dr. Donaldson, the chair of the department, told me that he was extremely happy about the performance of my students in the uniform common finals and that he had very positive feedbacks from other faculty members about me. Such positive feedback meant a lot to me so early in my career. At Howard, I found that I enjoyed working with students and learning from experts. I also enjoyed the company of collegial and friendly faculty members. Several faculty members attended my wedding reception as well as a baby shower organized by the staff of the mathematics department. The eight years I spent at Howard were formative for me.

Moving on to Morgan State

Unfortunately, my time there eventually ended and I left Howard in 1992. I joined the University of the District of Columbia (UDC) the same year. However, the budget crisis of the local government, which spilled over to the budget of UDC, made new positions there vulnerable, and I was ready for a more permanent position. In 1996, I got a call from Dr. Arthur D. Grainger, then chair of the mathematics department at Morgan State University (MSU), who asked me to join the mathematics department of MSU. And I did. I was hired first as a contractual faculty member, and soon after, in 1999, I became a tenure track faculty member; I was tenured in 2003. Today, I remain at MSU as an associate professor with tenure.

Dr. Grainger was one of the best administrators I was fortunate enough to work with. He was a brilliant mathematician and a man of few words, a man of integrity. His statements were thoughtful and clear; his word was his bond. I was lucky to have him as a colleague and the chairman, a person who truly cared about the quality of mathematics education offered to the students. He tolerated no nonsense and no shortcuts from students who went to him with complaints; he reminded them of the necessity of taking an active role in the process of learning. In the currently prevailing model of evaluating the performance of a faculty member based on the number of As and “DFW”s, he would surely be a misfit. But those students who came through his classes were fortunate since they all got a quality education. As I often remind my students, once they graduate from college and begin their career, what matters will be how well they can stand shoulder to shoulder and compete with any one of their peers from any other university. What distinguishes them will be how well they are trained and prepared.

The MSU mathematics department has friendly faculty members and staff, and our day-to-day lives are generally devoid of infighting. Irrespective of one’s position, everyone works together and helps to improve the quality and functions of the programs. Dr. Nathaniel Knox, a faculty member in the department when I joined, was always supportive; he told me more than once that my arrival had been good for the department and for the university. He would also encourage me, saying, “Doc, I know that showing off is not in your culture, here you have to show a little more”. He retired as Associate Provost and Vice-President for Academic Affairs. Throughout, he was always approachable when one needed guidance.

There have been many others who have helped me along the way because they saw something in me. At some point, I was approached by one of the subsequent chairs of the mathematics department at MSU, Dr. Gaston N’Guerekata, to take the leadership for a committee to write a proposal for a Ph.D. Program in Mathematics. I knew that the department had been trying to start a doctoral program for some time, so I asked him, “why me?” He answered, “if you took the leadership, it would be done”. Soon after, we formed a committee and I chaired it. We submitted our proposal to the Maryland Higher Education Commission (MHEC), and our Ph.D. for Industrial and Computational Mathematics (ICM) program was approved and began to admit students in 2011.

Students

During a meeting of the National Association of Mathematicians (NAM), someone asked my colleagues and me what the reason was for our department's success. My answer was, "our students are our ambassadors". I truly believe that.

I would not be the teacher I am without the help of my students over the years, though they may not be aware of their importance in my life. My office was often crowded with students. When I came back to my office from classes, there would be students coming along with me or already waiting there. I always had an open-door policy for my students, even outside of scheduled office hours. Sometimes they just needed a listening ear for their problems. I always encouraged students to get additional help coming to the office. For those courses, undergraduate as well as graduate, which required to write mathematical proofs, each student needed to come with his/her assignment and get them corrected when he/she was present. This gave me an opportunity to identify their weakness and guide them. They could rework those assignments and come to get the assignments graded. This individual mentoring gave them chances to learn and grow. Even though this approach took a lot more of my time, they were rejuvenating aspects of the profession. Towards the end of the semester, I found considerable improvement in the majority of my students. Often, graduate students from other countries commented that they did not get that sort of individual attention before. My topology classes at the graduate level were generally conducted by students, while I would be in audience asking them questions as they lectured on previously assigned topics. This was especially the case for the second semester course at the graduate level. This gave my graduate students the training to conduct a class and motivated them to do research on that topic.

Some accomplishments

Let me now mention some of my proud moments and accomplishments through my journey. The foremost of them were when my professors at UCC invited me to give seminars, whenever I visited India, addressing both graduate and undergraduate students. During those seminars, I spoke about how some of the basic results which they learn in early algebra classes can be effectively used to solve complex inequalities and they in turn can be utilized

to give alternate proofs of classical results in analysis; how the powerful exponential function can be developed and its properties explored using those basic results; how some fixed point theorems in analysis (topology) can be proved using the triangle inequality; how the fundamental properties of some results in analysis can be abstracted to expand them to uniform spaces in topology and how properties of the real number system can be used as a spring board to study some topological properties, to mention some of them. I saw and heard pride in my professors' address to the students, after my talk. As I indicated earlier, giving those seminars with my teachers in the audience, I was very proud. Materials for those seminars generally were based on some of my published articles, which were products of preparation for class lectures here in the United States.

It is usual for me to give talks at international conferences on topology and related fields. In 2009, I was one of the invited speakers for an international conference organized by the Kerala Mathematics Association along with other funding agencies, at St. Joseph's College, Iringalakuda, Kerala. Earlier I had given seminars there, addressing graduate and undergraduate students. During that meeting, Dr. T. Thrivikraman, a well-known topologist, stated that my previous seminar lectures motivated students there to be engaged to do research in mathematics. In 2016, I was a keynote speaker at an international conference organized by the Federal Institute of Science and Technology (FISAT), Kerala, India. There were articles about it in local newspapers. When my niece showed the news item with my picture on stage to my eldest sister, who brought us up after mother's passing, I saw pride in her eyes. Recently, I was invited to give webinars in FISAT and in UCC as it celebrated its centenary year. At the FISAT webinar, I spoke about topological boundaries and how the concept of a topological space encompasses different mathematical fields. I was asked to give the inaugural address as well as the inaugural lecture in the webinar series at UCC mathematics department, as part of the centenary celebration. At UCC, my talk was about how the compactness of a subset can change with slight variation in the topological structure of the space. Both talks were widely attended. The UCC principal forwarded some of the comments from students there requesting that they would like to have more talks like mine. That also was a proud moment for me, to be able to use my training to motivate others, especially students. It was deeply humbling and satisfying.

I have more than fifty research articles in refereed journals, published or accepted for publication, as I am continually engaged in research. Recently in 2022, a monograph, *A Study of Topological Properties Via Adherence Dominators*, written jointly by Professor J. E. Joseph and myself, was published in Lecture Notes in Nonlinear Analysis, published by the Juliusz Schauder Center for Nonlinear Studies, Poland.

Women in Mathematics: Some Reflections

I was asked very often, when I arrived in the U.S., if we had many female mathematics students and professors in India. I found that question strange since I always had female as well as male professors and researchers around. At Delhi University, female researchers Dr. S. P. Arya, Dr. Pushpa Jain, Dr. Asha Mathur, and Dr. Asha Rani Singal were all part of our weekly topology seminars, in addition to male professors Dr. J. K. Kohli and Dr. M.K. Singal. They were willing to help, whenever I needed, with research methodology using periodicals, as well as with subject matter itself. The Delhi University library had an excellent periodicals wing as well as a research scholars' floor. Each of the research scholars had a place to study there without any interruptions. Dr. J.K. Kohli was a regular there and I was glad that he was there for assistance in topics in topology. But female research scholars were numerous and were impactful. At UCC, in my M.Sc. class, the number of female students was more than three times the number of male students. Hence, the notion of women being competent mathematicians and researchers was not strange to me.

There have been dark times . . .

Inequality in treatment when it comes to tenure, promotions, recognitions, salary and working environment; all are sources of darkness and I faced all of them.

The latest force of darkness in its ugly form shook me off my ground, I have to admit. My daughter, who is now an OBGYN, told me in the summer of 2021 that she did not want to see me broken like that and asked me why I should go to work in a place where I was not appreciated. I had to correct her that, no, my department and my students knew and valued my work. Those who did not know or pretended not to know (for whatever reason) acted as agents of this vengeful darkness.

I recently attended a webinar, which focused on graduate students and faculty members in minority institutions. Speaker after speaker, when talking about female faculty members in the minority category, were invariably talking about African American female faculties. There is another class of female professionals who are judged with much higher levels of requirements when it comes to career advancement: female professionals who are foreign born. For a comment to this effect in the chat during that webinar, there were many responses in agreement. So, I do not believe that I am alone; I do believe that there are many who go through similar frustrating situations. When a task is to be completed, they would be approached, knowing that the work would be done and once the work is completed successfully, they often are pushed aside. As the times come to appreciate and reward them for their work, more and more requirements, not used for others in similar positions, creep in as darkness hindering their path of career advancement.

The summer of 2021 was extremely busy for me. Hiring committee work, evaluation of Ph.D. admission applicants, work for the College Board and Educational Testing Services, writing reviews of articles for *Mathematical Reviews*, editing and incorporating the comments of the reviewers of a monograph, preparation of courses for online teaching, and finalizing articles for publication . . . These activities are not unusual. We all use summertime to focus and complete such work, which I enjoy doing. What was unusual this past summer was that, with all the mental anguish of fending off the vengeful darkness, along with my busy schedule of work, which is usually a ray of happiness for me, my health deteriorated. I fell seriously ill and was in the Intensive Care Unit of the Johns Hopkins Bayview Hospital, Baltimore for almost three months. Except for my brain, every part of my body was affected.

. . . but the sun is sure to rise!

When I was in tenth standard, my father sat down next to me while I was doing my schoolwork as usual. He took one of my notebooks and wrote four lines of a poem he had just written for me. Here it is in translation:

My daughter, victory is at hand
for actions of an unwavering and incorruptible mind;
darkness envelops the world with vengeance,
but sun is sure to rise and rise it will.

As wisely and eloquently stated in those four lines by my father, on each of those dark moments I moved forward with the courage instilled in me by his prophetic message. While I was going through some of those dark moments early in my journey in this country, my eldest brother once told me that there was plenty of energy for destruction, but to stand up for what was right, there were only a few. The sun's rays came to chase away the darkness in rare professionals like Prof. James Joseph, Dr. Arthur Grainger, Dr. Nathaniel Knox and my friends and colleagues at MSU. My students are always a source of energy. Whatever hard time I am going through, when I am with students, in classroom or in the office, I see light, not darkness.

In terms of my health challenges, I am relearning to be normal and independent with the support of my family and the constant help provided by the medical community. My department and colleagues at MSU are very supportive. I was on medical leave during the 2021-2022 academic year, and resumed teaching online in the Fall semester of 2022, while going through physical therapies and further procedures for rehabilitation.

My parents' lives full of love and sacrifices, the lessons as exhibited through their exemplary living all are sources of guiding lights, illuminating the prevalent and vindictive darkness. As expressed with certainty in my father's message, the sun is sure to rise and rise it will.

For each of us, the family we are born into is our root; the love and support we receive throughout are sources of our nourishment, light and blessings. I certainly am blessed. The blessings of my father, mother, my eldest brother and sister from heaven are the rays of the sun. Those rays will guide me through this journey. My journey continues!