Girls in Math Prize – Maryam Mirzakhani Celebrations for Women in Mathematics 2021

Dr. Bhavani Thuraisingham

Extended Abstract

October 10, 2021

I was most honored to give the opening inspirational address to the Girls in Math Prize event as part of the Maryam Mirzakhani Celebration for Women in Mathematics this afternoon. This write-up is based on my address and focuses on the motivational aspect as well celebrating the contributions of the brilliant Maryam Mirzakhani who gave the world so much of beautiful Mathematics in her short 40 year life (1977 -2017). I will start with a brief background about how I evolved from a "*Girl in Math*" to a "*Woman in Computer Science*," what inspired me about Dr. Mirzakhani, and finally the motivational aspects of my talk.

My favorite subject was Arithmetic in Elementary School (K-G5) and then evolved into Mathematics in both Junior and Senior High Schools (G6-G12) in the cities of Jaffna and Colombo, Sri-Lanka (between 1959 and 1971 from the ages 4 to16) and consistently won the Math prize every year at the annual school prize giving. I was motivated by my mother who had wanted to pursue a degree in Mathematics but had to stop her education to get married. My mother's unparalleled encouragement and support had a tremendous impact on my higher education and career. I received a BS (first class) in Mathematics and Physics from the University of Ceylon (now Sri-Lanka), got married at 20 in 1975 and moved to England for my graduate education. I received an MS in Mathematical Logic from the University of Bristol, England and a PhD in Theoretical Computer Science from the University of Wales, UK. After an early five year career in Mathematical Logic and Theoretical Computer Science in the US starting in 1980 with several papers published in the Notre Dame Journal of Formal Logic and Mathematical Logic Quarterly as well as working as a senior software developer at Control Data Corporation working in computer networks and distributed systems (to earn enough money to supplement my husband's income), I moved into Cyber Security and Data Science in 1985 and for the past 36 years have been applying my logic and computability theory expertise at Honeywell, the MITRE Corporation, the National Science Foundation and UT Dallas with over 130 journal papers, 300 conference publications, 16 books, 7 US Patents and received the prestigious earned higher doctorate from the University of Bristol for my published research in data security. In addition to my mother, my role model was the brilliant mathematician Prof. Marian Pour-El at the University of Minnesota with whom I did joint research in Algorithmic Information Theory in early 1980s. We were working on finding analogies to Gödel's Theorems with respect to Kolmogorov Complexity Theory.

So now we come to the contributions of the most brilliant female mathematician in history and that is Prof. Maryam Mirzakhani. What she accomplished in 40 yrs. many of us will not living a full life. I heard about Dr. Maryam in 2014 when she became the first woman to get the Fields Medal in Mathematics. I started following her fascinating work. An excellent summary of her work is provided in https://www.mathunion.org/fileadmin/IMU/Prizes/Fields/2014/news_release_mirzakhani.pdf. At a high level, her work focused on Riemann surfaces and their moduli spaces. With this work she bridged the gap between multiple fields: hyperbolic geometry, complex analysis, topology, and dynamics. The Mathematician Riemann came up with the notion of abstract surfaces (in addition to concrete ones that we often come across) over 100 yrs. ago. Riemann then carried out complex analysis on the abstract structures. Riemann surfaces can also be defined in an alternative way and that is through Geometry. One such geometry is hyperbolic geometry which is a form of non Euclidean geometry. As stated in the article, "*Mirzakhani's early work concerns closed geodesics on a hyperbolic surface. These are closed curves whose length cannot be shortened by deforming them*." The article also states that "*Mirzakhani looked at what happens to the prime number theorem for geodesics when one considers*

only the closed geodesics that are simple, meaning that they do not intersect themselves." She then went onto prove many properties and provided answers to open problems in moduli space, some of which were around for close to 100 years. She continued to produce major breakthroughs during the latter part of her life including in "*understanding another dynamical system on moduli space that is related to the behavior of geodesics in moduli space.*" The article goes on to state that "*Non-closed geodesics in moduli space are very erratic and even pathological, and it is hard to obtain any understanding of their structure and how they change when perturbed slightly. However, Mirzakhani et al have proved that complex geodesics and their closures in moduli space are in fact surprisingly regular, rather than irregular or fractal.*" This renowned research by Mirzakhani and her two collaborators was a major breakthrough in Algebraic Geometry in general and in Moduli Space in particular. What is so unique about her is that she has an excellent understanding not only of the algebra but also of the geometry of the various structures and surfaces. Generations to come can build on her pioneering work and bridge the gap between the theories she has formulated and subsequently develop computational tools.

In many ways I wish I had come 20 yrs. after Dr. Maryam instead of 20 yrs. before her. She would have been my role model. In fact she is still my role model and would like to emulate her for the rest of my 15+ yr. career (hopefully 15+ more yrs. out of a total of 55+ yrs.). I have read that three attributes separated Maryam form others: Ambition (this is not ambition for success that many of us dream about, its ambition for achieving a breakthrough), Curiosity (she is always thinking in her mind about the abstract structures and the geometric representations) and Uncertainty (and that is not fear the unknown – she encounters a challenging problem and will go head on to solve it without any hesitation). With all these come determination, focus and hard work. It's hard for me, a mere mortal, to even imagine how a brilliant mind likes DR. Maryam's works. I suppose whenever she reads about structures she starts building a visual picture in her mind and refines it until it is clear. Unfortunately I did not have the privilege to talk to her.

This brings me to the last point – even though many of you "*Girls in Math*" may not have met her also, at least you have a great opportunity to emulate her and follow in her footsteps. Perhaps you could even follow up on her research and continue to make major breakthroughs like she did. One thing common to all of us is that we are all women and we all love Mathematics. While there are some challenges that women face that men do not, like giving birth to children and raising children (in most families), women also have many qualities that are special such as caring, empathy, and hard work as we have so much to do and juggle between tasks. But remember, we are as clever as men or even better due to our additional attributes and we can do whatever men can in Mathematics. Therefore, never let anyone undermine you and never give up during times of frustration. Remember you are a brilliant mathematician. Also, Mathematics does not discriminate with respect to color, religion, ethnicity, and gender (among others). It's the people who discriminate and what we have to make sure is that everyone has the opportunities to thrive in their education and succeed. Remember I am a woman of color from a poor third world country (Sri-Lanka) and belonging to a minority race (Tamil). It was not easy to succeed in that environment, but I never allowed external events to affect me. The more people put me down the more determined I become to succeed. I was of course fortunate to have a mother who believed in me and always said I can do anything. That enabled me to succeed in my Mathematics education and now a successful career in Computer Science that evolved from Math.

I would like to leave you with the following words. "*Mathematics is the Queen of Science and if you master it you can do anything.*" I would also like to add "*Nothing can be more intellectually challenging and yet more rewarding and more beautiful than exceling in Mathematics.*"

Dr. Bhavani Thuraisingham's Evolution from a Girl in Math to a Woman in Computer Science

Dr. Bhavani Thuraisingham is the Founders Chair Professor of Computer Science and the Founding Executive Director of the Cyber Security Research and Education Institute at the University of Texas at Dallas (UT Dallas) and also a visiting Senior Research Fellow at Kings College, University of London. Currently she is a Senior Strategist in Cyber Security and Data Science and the founding Co-Director of both the Women in Cyber Security and Women in Data Science Centers.

Bhavani's favorite subject was Arithmetic in Elementary School (K-G5) and then evolved into Mathematics in both Junior and Senior High Schools (G6-G12) in the cities of Jaffna and Colombo Sri-Lanka (between 1959 and 1971 from the ages 4 to16) and consistently won the Math prize every year at the annual school prize giving. She was motivated by her mother who had wanted to pursue a degree in Mathematics and had to stop her education to get married. Her mother's unparalleled encouragement and support has had a tremendous impact on Bhavani's higher education career. Over the past 41 years, Bhavani's career has evolved from Mathematical Logic and Theoretical Computer Science to the Theory and Practice of Cyber Security and Data Science. Bhavani received a BS (first class) in Mathematics and Physics from the University of Ceylon (now Sri-Lanka), an MS in Mathematical Logic from the University of Bristol, England and a PhD in Theoretical Computer Science from the University of Wales, UK. After an early five year career in Mathematical Logic and Theoretical Computer Science with several papers published in the Notre Dame Journal of Formal Logic and Mathematical Logic Quarterly, she has worked in Cyber Security and Data Science for the past 36 years applying her logic and computability theory expertise at Honeywell, the MITRE Corporation, the National Science Foundation and UT Dallas with over 130 journal papers, 300 conference publications, 15 books, 7 US Patents and received the prestigious earned higher doctorate from the University of Bristol for her published research in data security.

Bhavani is an elected Fellow of multiple reputed organizations including the ACM (Association of Computing Machinery), the IEEE (Institute of Electrical and Electronics Engineers), the AAAS (American Association for the Advancement of Science), the NAI (National Academy of Inventors) and the British-based IMA (the Institute of Mathematics and its Applications). She has received several technical awards for her research including the IEEE Computer Society's 1997 (Edward J. McCluskey) Technical Achievement Award and the ACM Data and Applications Security and Privacy 2017 Lasting Research Award, and has delivered over 180 keynote and featured addresses at research conferences.

Bhavani has been a passionate advocate for Women in Mathematics and Computing and has given around 40 keynote and featured addresses at outreach events including at Women in Cyber Security and Women in Data Science focusing on the Role of Mentoring for the Advancement of Women. She has received multiple awards for her outreach work including the 2001 Woman of Color Research Leadership Award from Career Communications Inc., the 2017 Dallas Business Journal Women in Technology Award, and the 2021 IEEE Cyber Security Cloud Special Recognition Award for Diversity, Equity and Inclusion. Her role models are her late mother whose aspiration was to be a mathematician and the brilliant mathematician the late Prof. Marion Pour-El at the University of Minnesota with whom she conducted research on Algorithmic Information Theory in the early1980s. She has balanced her graduate education and career with marriage, motherhood and grand-motherhood for the past 46 years through hard work, focus, determination, organization, compromise and cooperation.

She states that "*Mathematics is the Queen of Science and if you master it you can do anything.*" She also adds that "*Nothing can be more intellectually challenging and yet more rewarding and more beautiful than exceling in Mathematics.*"