Making it in the mathematical community: the case of women mathematicians in Hungary

By
Sneha Narayan

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Professor Éva Fodor

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Abstract

In this paper, I trace the experience of several women mathematicians in Budapest, and examine the circumstances under which they achieved success in their field. I first introduce the existing research on women in science (largely conducted in the United States), which includes a discussion on how science came to be masculinized, how being a woman and a scientist is perceived to be an apparent contradiction in public images of science, and the effect that community formation has on helping women build an identity for themselves as mathematicians. I then go on to analyze interviews of four different Hungarian women mathematicians using these theories, but also attempt to locate these experiences as a part of the historical development of mathematics in Budapest. Finally, I show that much of the theoretical literature broadly applies to the lives of Hungarian mathematicians as well, while highlighting a few key places in which the experience of Hungarian women mathematicians differs from the experience of American mathematicians.

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Chapter One: Introduction

"As soon as we are interested in understanding the world, we don't look at mathematics as a profession, but as part of science, or human inquiry into the world… if we look at mankind's history and look at it as just one huge endeavor, then we need all kinds of people to understand this - not just men." - Imre

While I was interviewing Adrienn[1] about her experiences as a woman mathematician in Budapest, her husband Imre quietly interjected with the quote at the top of this page, which happens to neatly encapsulate the *raison d'etre* of this investigation. Science and mathematics in modern times have been crucial in shaping our understanding of the world, and in providing a basis for technological innovation and advancement. Scientific and mathematical knowledge has molded our worldviews, pervaded our education systems, and influenced our politics – yet much of the social process of how this knowledge is produced remains largely ignored by most of society that benefits from the results of science and mathematics.

When considering science and mathematics as socially and historically rooted methods of knowledge production, we must ask ourselves who typically has shaped the history of these forms of inquiry. The production of science and mathematics has been almost entirely in the male domain, and it is only in very recent times that we have seen a steady rise of women entering these fields as well. This paper seeks to explore the ways women overcome the hurdles that they experience in order to succeed in the male-dominated field of mathematics. I focus specifically on the case of women mathematicians living and working in Budapest.

[1] All names changed to protect privacy

I will first examine the literature the surrounds women in science in Chapter 2 – from how mathematics and science (indeed rationality itself) came to be constructed as a masculine endeavor, and how this construction continues to affect the public perception of math and science even today, to the ways in which women entering science have been able to surmount challenges and enter the field in steadily growing numbers.

Chapter 3 introduces the reader to the backgrounds of the informants consulted for this project, and describes the methods used for research, including limitations. Since the theoretical literature on women in science is largely centered around studies conducted in North America, I take the reader through a short overview of the history of the mathematical community in Hungary from the mid-19th century to the present, in Chapter 4. This serves to establish the context within which the analysis is located.

In Chapter 5, I conduct an in depth analysis of the interviews of the informants, focusing on what challenges they faced (or did not face) as mathematicians, and how they were able to surmount them. According to the interview data, it can be seen that mathematics is generally perceived as a male endeavor in Hungary, yet that the women mathematicians I interviewed have carved out an identity for themselves within the mathematical community by attempting to redefine the rhetoric and practice of the field, at least for themselves, and emphasizing its co-operative aspects. It is also seen that these women emphasize, over everything else, the way that the community of mathematicians that they have found and are involved with are instrumental to their success, enjoyment and passion for the field. The specific dynamics of Budapest as a city are explored to examine how these mathematical communities are formed and sustained.

Chapter Two: A theoretical and historical overview of women in science

Mathematics has long been described variously as ‘pure’, and ‘objective’, and many of those who pursue it (and even those who do not) attempt to claim that its abstraction puts it in a realm beyond that of the natural world, making it impervious to social processes. Despite the admittedly high degree of consensus that exists in mathematics, it, like any other human pursuit, is undoubtedly shaped by history and society. The purpose of this chapter is to call to the attention the historical development of mathematical and scientific inquiry, highlight the various social structures that exist in the scientific community, and address how the community of scientists and mathematicians are reproduced and viewed by the public. Much of the literature that is reviewed in this chapter is admittedly centered on research conducted in North America, and represents many dominant perspectives in feminist studies of science, employment and education. However, as will be demonstrated in Chapters 4 and 5, while these studies provide a solid framework from which to analyze the experiences of women mathematicians in other countries, specific histories and locations do matter. It will be seen that while these theories provide perspective on women in male-dominated fields, the experiences of women mathematicians in Hungary will allow us to view these theories in a new light.

2.1 The masculinization of rationality

One of the challenges that women face in entering and succeeding in the realm of mathematics is that both historically and presently, the rhetoric that surrounds the pursuit of mathematics and science is gendered. Many feminist critiques of science note the way that the scientific process has historically been defined as something that is masculine, in that it exists in opposition to femininity.

What is understood today as the modern scientific method is based on a long history of ideas, some of the earliest of which were attributed to the Greeks. Nature and its mysteries were typically associated with femininity in early Greek literature, as evidenced by portrayals of natural forces as earth goddesses with dark powers.[2] Science and reason were the way that these forces could be overcome, and since order and clarity were defined in contrast with the indeterminate, disordered ways of Nature, rationality came to be associated with masculinity. In her analysis of early Greek thought, Genevieve Lloyd claims that “the pursuit of rational knowledge has been a major strand in western culture’s definitions of itself as opposed to Nature… Rational knowledge has been construed as a transcending, transformation or control of natural forces; and the feminine has been associated with what rational knowledge transcends, dominates, or simply leaves behind.”[3]

Many early philosophers espoused the notion of associating the rational with the masculine, and their ideas have shaped modern science and mathematics over the course of many centuries. The Pythagoreans, who were a society of thinkers considered to be among the first mathematicians, saw the world as a dichotomy of principles. Concepts that were clear, precise and determinate were viewed as superior to those that were

[2] Lloyd, Genevieve. 1996. “Reason, Science and the Domination of Matter”, in *Feminism and Science*, edited by Evelyn Fox Keller and Helen E. Longino. Oxford University Press, New York, p. 42.
[3] Lloyd, Genevieve, 1996, p. 41.

indeterminate, vague and disorderly. These notions of order and rationality were explicitly linked to masculinity, and existed in opposition to notions of disorder and limitlessness typically associated with femininity. The Pythagoreans influenced Plato, who further extended the Pythagorean theory of knowledge to claim that knowledge exists in an abstract form, totally separate from and devoid of connection with the natural world. Knowledge, in the Platonic ideal, exists solely in the mind, and independently of the natural world – it is pure abstraction that is unfettered by the imprecision and lack of perfection in the nature. Thus, Plato too defined rationality as existing separately from, or leaving behind, the feminine natural world.[4]

While this rhetoric of masculinizing reason was used as far back in 6th century B.C., the impact of Platonic philosophy on mathematics today is undeniable. The Platonic view of mathematics as a perfect realm that represents a higher truth, independent of the vagaries of nature, is espoused by many working mathematicians and philosophers even today[5], which serves to both establish mathematics as ahistoric as well as obfuscate the gendered social processes that underlie it. As the scientific revolution swept Europe in the 17th century, the rhetoric surrounding mathematical and scientific inquiry became even more explicitly gendered. Two of the most prominent scientists of that era were René Descartes, who pioneered analytic geometry and advocated rationalism, and Francis Bacon, who introduced the philosophy and practice of what is known today as the scientific method. Upon undertaking a psychoanalytic reading of Descartes' *Meditations*

[4] Lloyd, Genevieve, 1996, p. 43.
[5] Davis, Philip J., and Hersh, Reuben, 1998, *The Mathematical Experience*, Bikhauser, Boston, pp. 318-330.

of First Philosophy, Susan Bordo (among others) concludes that Descartes envisioned rationality as a "'flight from the feminine' rather than (simply) the confident articulation of a positive new epistemological ideal"[6], due to his anxiety over the untamed, feminized natural world. Descartes too had a significant impact on mathematical thought – besides developing the Cartesian co-ordinate system, now part of foundational secondary school mathematics, his devotion to rationalism and insistence that deduction from first principles was the only sure way to truth played a large part in the way mathematicians viewed their own field.

However, few cornerstone writings about the philosophy of science and mathematics are as explicitly gendered as Francis Bacon's. The task of science, according to Bacon, was to exert the correct form of dominance over Nature, expressly presented as female. Lloyd deconstructs a series of quotations from Bacon's writings:

"'Let us establish a chaste and lawful marriage between Mind and Nature,' he writes. The right kind of nuptial domination, he insists is not a tyranny. Nature is 'only to be commanded by obeying her'. But it does demand a degree of force: 'nature betrays her secrets more fully when in the grip and under the pressure of art than when in enjoyment of her natural liberty.' The expected outcome of the new science is also expressed in sexual metaphors… the most striking of [which]… are in an early, strangely strident work entitled *The Masculine Birth of Time*. 'I am come in very truth', says the narrator in that work, 'leading to you Nature with all her children to bind her to your service and make her your slave.'"[7]

The purpose of bringing to light these historical discussions of science and rationality is to demonstrate that while science and mathematics make claims towards objectivity, the rhetoric that surrounds the literature that led to modern day science clearly portrays the

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[6] Bordo, Susan, 1987, "The Cartesian Masculinization of Thought", in *Sex and Scientific Inquiry*, edited by Sandra Harding and Jean F. O'Barr, University of Chicago Press, Chicago, p. 249.
[7] Lloyd, Genevieve, 1996, pp. 47-48.

activity of doing science as a masculine endeavor, working against the feminine. It can be argued then that from its early definitions onwards, science as a social activity was certainly considered male not only because women were physically excluded from its practice, but also because it was theorized to require a male mind to even pursue it.

2.2 Popular images of male and female scientists, and the double bind

While it is true that students in modern day science and mathematics classrooms do not generally read Plato or Bacon, the legacy of these thinkers on the culture and rhetoric that surrounds current scientific practice is evident. Marcel C. LaFollette analyzed public images of science in the first half of the 20th century, and much of her analysis demonstrated that science was perceived to be a predominantly a (white) male activity[8], and scientists were stereotyped as unemotional, robotic and dispassionate[9] – people who surveyed the world from a distance, in much the same vein as described by earlier philosophers of science. Popular images of scientists mirrored these gendered stereotypes quite closely, serving to perpetuate the notion of science as a male activity well into the modern era.

LaFollette observes that the vast majority of popular scientific articles and biographies were written by males, about males, and that "most magazine descriptions of scientists implied that success in scientific research required certain 'masculine' attributes such as

[8] LaFollete, Marcel C., 1990, *Making Science Our Own: Public Images of Science 1910-1955*, University of Chicago Press, Chicago, p. 74.
[9] LaFollete, Marcel C., 1990, p. 67.

intellectual objectivity, physical strength, and emotional detachment."[10] Science thereby came to be viewed by the public (and not just antiquated philosophers) as requiring masculinity in order to be practiced correctly.

The few biographies that did exist about women scientists at that time demonstrated how being a woman and being a scientist was an apparent cultural contradiction, that needed to somehow be explained or justified in virtually every instance such profiles were written. For instance, biographies of Marie Curie described the physicist's accomplishments in detail, but also made sure to note how she was devoted to her husband and children. LaFollette observes:

"In science, professional women were said to be "borrowing… many hard and objective qualities from the other sex," yet nonetheless making "exquisite and easy adjustment of both sides of life- the tough and the tender, the hard work and the human relations- without sacrificing the virtues of either.""[11]

The notion of 'adjustment' of a woman's 'natural feminine side' with the more 'masculine traits' involved in practicing science, demonstrates the fact that women were expected to reconcile these two seemingly opposite requirements in order to be praised for their work. Indeed, a 1926 biography of Alice Hamilton, a noted public health specialist who was the first woman to be invited to the Harvard medical faculty, lamented the fact that Hamilton was unmarried and childless, and further claimed that she was "compelled to abandon well tried domestic paths"[12], implying that this was in some ways a necessity in order to succeed in a male-dominated field.

[10] LaFollete, Marcel C., 1990, p. 79.
[11] LaFollete, Marcel C., 1990, p. 86.
[12] LaFollete, Marcel C., 1990, p. 86.

Despite the fact that many male scientists of that time had families, men were not held to the same expectations of domesticity. In fact, in the event that they withdrew from family life, it was lauded as a testament to their devotion to their field of choice. Biographies of male scientists praised their long hours spent in the laboratory, absentmindedness and lack of social skills because it evidenced that these men of science were not concerned by the trivialities of daily life. Women scientists, however, were not only expected to excel at their work, but also expected to maintain their roles as wives and mothers – abdicating these responsibilities was not just considered unfeminine, but also inappropriate.[13]

This particular predicament faced by women in science, and in fact other male-dominated fields as well, is theorized as a double bind. When the field that a woman participates in is so heavily masculinized, the woman in question is either not seen as competent to perform in the field (she is too 'feminine') and in the event that she does succeed in the field, she is regarded as less of a woman. The double-bind faced by women in male-dominated fields is fleshed out in detail by Jennifer Pierce in her research on the way gender is performed in law firms (another heavily masculinized profession) and it applies analogously to women in science and mathematics.[14]

A popular joke among mathematicians in the 20th century illustrated the double-bind that women mathematicians faced. The joke, commonly attributed to Hermann Weyl, a renowned German theoretical physicist, went as follows: "There have been only two

[13] LaFollete, Marcel C., 1990, p. 87.
[14] Pierce, Jennifer L., 1995, Gender Trials: Emotional Lives in Contemporary Law Firms, University of California Press, Berkeley and Los Angeles, pp. 103-142

women in the history of mathematics. One of them wasn't a mathematician [Sonia Kovalevskaia], the other wasn't a woman [Emmy Noether]."[15] Claudia Henrion's compilation of biographies of women in mathematics helps us put this joke in context. Sonia Kovalevskaia and Emmy Noether are two of the most celebrated women mathematicians in history. Noether was a German mathematician who completely revolutionized her field of abstract algebra, and the Noetherian ring is an algebraic structure named after her. Sonia Kovalevskaia was a Russian mathematician who completed three doctoral dissertations, won the prestigious Prix Bordin Prize and went on to become one of the first women to hold a full professorship in Europe. However, Henrion notes that Noether was famously regarded as unattractive and masculine looking (and even was given a masculine title – "Der Noether"), and so her acceptance as a mathematician was "facilitated by the fact that her colleagues did not see her as a typical woman."[16] Kovalevskaia on the other hand, was conventionally attractive, and was a wife and a mother. But despite her undoubtedly significant contributions to mathematics, she still did not fit the popular profile of a mathematician, as she was too feminine[17]. For all their accomplishments, Noether and Kovalevskaia still faced judgment about their femininity or questions about their competence due to their gender. Given these conflicting expectations for women, there seemed to be no way to be above reproach as a woman mathematician.

[15] Koblitz, Ann Hibner, 1996, "Mathematics and Gender: Some Cross-Cultural Observations", in *Towards Gender Equity in Mathematics Education*, edited by Gila Hanna, Kluwer Academic Publications, pp. 93-110.
[16] Henrion, Claudia, 1997, *Women in Mathematics: The Addition of Difference*, Indiana University Press, Bloomington, pp 68-69.
[17] Henrion, Claudia, 1997, p. 69.

2.3 The double-edged effect of female role models

Weyl's contention that there were only two women mathematicians in history not only effectively illustrated the double bind that women faced, but also silenced the many other contributions made by women to mathematics. As such, before the 19th century, it was very unlikely for women to be credited for the work they did in science and mathematics, as they were seldom even allowed to attend higher educational institutions. Sophie Germain, for example, was a woman who lived in 18th century France with a deep passion for mathematics. She independently pursued this interest despite being discouraged by her parents and being barred from studying at the Ecole Polytechnique, and went on teach herself mathematics by borrowing lecture notes and corresponding with other mathematicians via mail under a male pseudonym. She went on to make several important discoveries in the mathematics of elasticity, and carved out some foundational work on the proof of Fermat's Last Theorem, which mathematicians worked on for hundreds of years till it was eventually proven in 1995. She had no professional training or credentials, which meant that it took many years for her to be considered a fellow mathematician by her contemporaries, yet her impact on mathematics was undeniable.[18]

Germain was certainly exceptional, as were other women mathematicians and scientists in history who defied traditional gender expectations to go on and produce research despite all odds. Stories of women like Germain, Noether and Kovalevskaia are of crucial importance to understanding science as a historical process, as they reveal not only

[18] Dubreil-Jacotin, Mary-Louise, 1971, "Women Mathematicians", in *Great Currents of Mathematical Thought,* edited by F. Le Lionnais, Dover Publications, New York, p. 168.

important aspects of the progress of scientific ideas, but also the ways in which science developed and progressed as a social practice. As more women entered science and mathematics in the 20th century, more biographies describing the accomplishments of pioneering women scientists such as Germain were published. However, despite the steady rise of women in science in the 1900s, their portrayal in popular science magazines occupied one of two extreme positions. Either they were referred to in passing as subordinate lab assistants (roles which were disproportionately common for women to occupy as they initially entered the field), or as superhuman, in that their genius was so extraordinary that the male-dominated scientific community had to sit up and take notice. LaFollette observes that “only males were the subjects of articles about ‘normal’, ‘ordinary’ or ‘everyday’ scientists. Women scientists… were depicted as something more than ordinary, as not only exceptional scientists but also exceptional women… By focusing on the exceptional woman, the magazines reinforced cultural stereotypes of women scientists as glamorous stars in the drama of science, but not as indispensable links in the process.”[19] While history (as well as the present) is indeed peppered with exceptional male and female scientists, the fact that women are portrayed strictly as either subordinate or superhuman sets up a false set of choices for women entering science – that if a woman is not uncommonly prodigious, she could not be successful at all in science.

While the stories of exceptional women mathematicians are certainly to be shared widely, and the history of their struggles inform us about how scientific culture has progressed

[19] LaFollette, Marcel C. 1990, p. 92.

over the years, the fact that women in mathematics are represented by just a handful of stars perpetuates the notion that being both mathematician and a woman is a superheroic effort, which could deter women from entering the field in the first place. "By implying that the options of a regular family life, home and possibly motherhood were closed for all but the superwomen, this public image may have dissuaded many students from choosing scientific careers,"[20] suggests LaFollette.

These images not only affect students, but also other professional mathematicians. For instance, the expectation that a woman needs to be exceptional and far superior to her male peers in order to succeed is often present in hiring committees. Sue V. Rosser surveyed women scientists in the United States in order to examine the kinds of challenges they faced in their professional lives, and a common response was that women needed to fight to be taken seriously. One respondent claimed that "women have to go farther, work harder and accomplish more in order to be recognized"[21]. Another said, "Women have to prove their competence, whereas men have to prove their incompetence. For example, I have often heard men question whether a particular woman scientist… actually contributed substantially to the work she presents; whereas, I have never heard a man questioned on this."[22] Both these responses stem from the publicly held notion that women have to prove their worthiness above and beyond that of their male peers in order to be considered for the same positions, and this in turn arguably stems from the fact that

[20] LaFollette, Marcel C. 1990, p. 94.
[21] Rosser, Sue V., 2004, *The Science Glass Ceiling: Academic Women Scientists and the Struggle to Succeed*, Routledge, New York, p. 40.
[22] Rosser, Sue V., 2004, p. 41.

the ‘ordinary’ scientist is expected to be male. Throughout the course of science, alongside the (male and female) geniuses who are remembered for centuries, were also many competent scientists who perhaps did not go down in history, but were successful nonetheless. The historical moments in science were attributed to the tiny minority of those who participated in its creation, but were in fact possible due to many minor contributions along the way. It is indeed possible to be a successful scientist and do worthwhile work while being merely competent rather than historically prodigious, yet the common perception that these ‘everyday’ scientists are men makes it difficult for women to enter these ranks en masse.

2.4 Locating oneself in the mathematical community

Research in education and pedagogy has shown that these images of science and mathematics are indeed significant in terms of whether or not women choose to enter mathematics. LaFollette claims that “women are penalized even before they begin to compete”, as the popular images of science show the field as inappropriate for women. A study of American undergraduate women has shown that while new educational programs for women might help, they often played a less significant role than “the set of conceptions, predispositions and expectations”[23] that each student has about science. “Women enter college with different notions, implicit if not explicit, of what science will be like and the role it will play in their lives”, the authors argue, and suggests that for change to occur, women would need “to feel that being a scientist is appropriate, normal and not unfeminine.”

[23] Ware, Norma C., Steckler, Nicole A., Leserman, Jane, 1985, “Undergraduate Women: Who Chooses a Science Major?”, *Journal of Higher Education*, Vol. 56, p. 82.

With the weight of these impressions about femininity existing in opposition to mathematical culture, what has contributed to the rise of women in mathematics in the 20th century, and how are these perceptions challenged? Much of the research in the area suggests that women who succeed in mathematics tended to have been able to develop their own identity surrounding their mathematical pursuits, usually through inclusion in a community. Henrion observes that the common theme that runs through all the biographies that she has compiled of women mathematicians through interviews is that they consistently managed to find some sense of community at some point in their lives, and that this was instrumental to their commitment to mathematics. She writes: "Once the mathematical fire is lit, it must be sustained by a community of peers who help stoke it. A critical role of community is to create a sense of belonging, a kind of mathematical family with whom one identifies. For women this can be particularly important because women who are deeply interested in mathematics are more likely to be socially ostracized than men."[24] Thus Henrion points to being part of a community as a way to circumvent the 'double-bind' presented to women in science – if a woman is accepted as a member of a group of mathematicians, she is likely to be accepted and assessed as an individual, rather than as an example of her gender.

There has also been research that has shown that sheer numbers often help. If there are more women in a program, it is less likely that women would be stereotyped or pigeonholed as a group one way or another. An example comes from Pat Rogers, who

[24] Henrion, Claudia, 1997, p. 10-11.

conducted research at State University of New York at Potsdam, a research university noted for its wildly successful ability to attract women to mathematics. At the time of the study, 60.4% of all undergraduate math degrees at SUNY Potsdam were awarded to women, at a university were 55% of the undergraduates were female. When math majors at SUNY Potsdam were interviewed, they "expressed profound ignorance of the fact that females were often discouraged from taking mathematics. Only a few students admitted to be aware of the stereotyping of mathematics as a male domain."[25]

Conversely, extensive research has also been done on the experience of being the only, or one of the few, women in the field. In particular, Rosabeth Kanter[26] makes the argument that the relative numbers of women to men in a group affects how women perform. She makes this claim about women in management, but her ideas are very applicable to a wide variety of male-dominated fields, including mathematics. She observed when women occupied a small minority of positions in a department of a corporation, they became 'token' examples of their gender. Being a token woman meant that you were very visible, and that your performance was thought to indicate what any woman was capable of. This put women under tremendous performance pressure – Kanter claims that this alternately leads to women working extra hard to perform above and beyond their male peers to prove their worth (leading to burnout), or rendering themselves invisible within their work environment, to avoid even more scrutiny than they were already undergoing. Thus, isolation and tokenism could be detrimental to a person's performance

[25] Rogers, Pat, 1990, "Thoughts on Power and Pedagogy", in *Gender and Mathematics: An International Perspective*, edited by Leone Burton, Cassell Education, Strand, p. 53.
[26] Kanter, Rosabeth, 1977, *Men and Women of the Corporation*, Basic Books, Chapter 8: "Numbers: Minorities and Majorities".

in a group particularly in an environment where one was required to prove one's worth as an individual against the worth of others.

2.5 Balancing work and family

A large issue involved in entering a male-dominated profession is that since the people working in it have historically been male, the administrative and bureaucratic features of the profession tend to be constructed to work primarily for men. One way in which this often plays out is when women choose to give birth – pregnancy and child rearing often requires taking time away from a profession, and in order for women to be able to successfully return to work after a leave of absence, the profession needs to be structured in order for this to be possible.

Academia is famously an avenue where balancing work and family is difficult. Arlie Hochschild[27] examines the situations of female graduate students and professors of sociology at UC Berkeley and UC Santa Cruz, and demonstrates how academia structured in such a way that it is intensely difficult to get through graduate school as a mother, or work towards tenure while raising an infant. She points out that tenure review comes in most academic's lives right around child-bearing age, and that women are applying for tenure later, or giving birth at very late ages. As such, these timelines are adjusted to 'male clockwork' and while women are joining these professions nonetheless, they do so often while making tremendous personal sacrifice. Hochschild makes these

[27] Hochschild, Arlie Russell, 1994, "Inside the Clockwork of Male Careers", in *Berkeley Women Sociologists: Gender and the Academic Experience*, University of Nebraska Press, Lincoln, Chapter 10.

claims as a sociologist studying her own experiences and the experiences of other female sociologists, but this theory could just as easily be applied to mathematics. Hochschild also writes about the unequal share of responsibilities that are undertaken by women and men in terms of raising a family in *The Second Shift*[28] – she shows that women with careers as well as a family end up working far more hours than men do, and often suffer from exhaustion due to the dual jobs they have at work and at home.

Rosser[29] examines the ways in which women scientists struggle to balance work and family. She cites an informant who chooses to spend only 40 hours a week working, because she wishes to spend the remaining time with her son, but she knows this comes at the cost of being more “successful” in the field, in that she knows that people (most often men) who are at work 60-80 hours a week produce more research. The informant protested that she needed to choose between either a career as a prominent scientist, or becoming a mother. Rosser herself notes that “balancing the tenure clock with the biological clock challenges women scientists and engineers who want to become biological mothers in ways never faced by men since they cannot become pregnant.”[30]

It is to be noted that the standards of performance in male-dominated fields are often set by the accomplishments of men who do not have a ‘second shift’ – therefore, in order for a woman to accomplish these standards and prove herself to be competent, women often have to not just do as well as their male counterparts, but better. Given that women are

[28] Hochschild, Arlie Russell, *The Second Shift*, Penguin Books, New York.
[29] Rosser, Sue V., 2004, p. 38.
[30] Rosser, Sue V., 2004, p. 42

responsible for giving birth and often responsible for infant care, the challenge to be 'better' than men is already being played out on an uneven playing field. Thus, even very competent and capable women scientists often feel the urge to leave academia, because of the difficulty of being a mother and a scientist.

Chapter Three: Methodology

I chose to interview several Hungarian women mathematicians in order to examine how and to what extent their experiences in mathematics fit into the theoretical and historical framework presented in Chapter 2. I emailed interview requests to eight women mathematicians living in Budapest that I could find contact information for on the internet. Out of these, four responded, and I interviewed all four. In addition to these four mathematicians, I interviewed Miklós[31], a prominent member of the Rényi Institute, to gain perspective on the history of the Hungarian mathematical community, as well as its practices today.

All four mathematicians had full-time positions as researchers/professors at well-known institutes in Budapest. Adrienn and Rózsa were born and raised in Budapest, Izabella was born in a small town in Hungary, and Márta was an ethnic Hungarian from Serbia. All four mathematicians were educated in Budapest from the undergraduate level onwards. Each mathematician was interviewed for about a little over an hour. The interview focused on charting their progression through their mathematical careers, and attempting to identify any challenges that they faced based on their gender. Additionally, the interviewees were asked to discuss how collaboration took place. A list of questions that were covered is attached in the appendix; however, the interviews were semi-structured, and often deviated from the order that is presented.

3.1 Background of the informants

[31] All names of interviewees are changed to protect privacy.

Rózsa was born in 1930, yet is still an active researcher even today. She is one of the most prominent and respected mathematicians in Hungary today, and has over the course of her life held prestigious positions in institutions both in Hungary and abroad. She still travels extensively to conferences around the world, and publishes papers with many different co-authors. She was a noted contemporary of Paul Erdos, who was perhaps one of the most famous and prolific Hungarian mathematicians alive. Rózsa is an example of a woman who undoubtedly 'made it' in the mathematical community, and analyzing her story can help us understand some of the factors that help women succeed in mathematics.

Adrienn, like Rózsa, is also a successful mathematician. She was born in 1947, and is again, still very active in her research. After graduating from university with a degree in research mathematics, she worked as a software engineer in the 70s. At the software firm she worked at, she became interested in theoretical problems in computer science, which eventually led her back to pure mathematics, and she decided to eventually pursue a doctoral degree. She was one of the very few mathematicians of her time (and the only person I interviewed) who did not go straight into a doctoral program after she finished university. She met her husband Imre during her days as a software engineer, and till today, they primarily collaborate on mathematics with each other.

Márta was born in the early '70s, in Novi Sad, Serbia. She came to Hungary in 1990 to pursue a degree in mathematics, after she won a scholarship to study in Hungary. She joined Adrienn's research group in 1995, and completed her PhD in 2003. She and Adrienn continue to do research together, along with Adrienn's husband.

Izabella was born in the mid-1950s, in a small town in the Hungarian countryside, and attended an advanced secondary school mathematics program in a different town. She then attended university in Budapest, and went on to obtain advanced degrees in mathematics. She worked for some time as a researcher in some fields of applied mathematics, before she moved to a teaching position at a Hungarian university.

3.2 Possible sources of bias from informants

There were a few issues to work around while interviewing the informants. Rózsa and Márta mentioned immediately upon hearing my research topic that there was no difference between male and female mathematicians, and denied having been treated differently, or having seen such differences themselves. This immediate reaction concerned me, not because I thought this was an illegitimate opinion to have, but because I was worried that such a conclusion before the interview even began would limit how much they were willing to dwell upon their experiences when asked about them, or that I was viewed as a person with an oppositional perspective that needed to be debated against, rather than conversed with. However, I had anticipated receiving this reaction from at least a few informants, and saw my goal in these situations to nevertheless persuade them to reflect on their backgrounds, regardless of their initial response. I explained to both of them that it was still interesting to hear about their backgrounds and career progressions for my research, even if they felt like they were never treated differently. Eventually, they did provide many interesting, nuanced insights about their lives as women mathematicians, yet it is to be remembered that they began from a position of defensiveness.

In addition to her initial reaction to my research, Márta also had reservations about being recorded, and was significantly more reluctant to answer the more personal questions in the interview. As a result, much of the interview was recorded through notes (which she was fine with), and hence a greater part of my final notes on this interview were based on my personal recollection of the event, compared to the other interviews. Additionally, her reluctance caused her to give rather abrupt answers at the beginning, which occasionally contradicted her answers later in the interview, after she was gently persuaded to reflect on the topics that made her feel the most vulnerable. Her reluctance to speak could be seen as a bias, in that she may not have been fully comfortable sharing all the details of her experiences, but I believe it also serves to highlight the fact that the things that she finally revealed were of considerable emotional significance.

Another source of potential bias was present in Adrienn's interview, where her husband Imre (who was also her colleague) asked if he may sit in and listen to the interview. As the interview was held in their home, I did not feel comfortable asking Imre to leave, so he stayed and listened to the interview. This initially concerned me, as I was worried that having her husband present may significantly bias Adrienn's answers, especially regarding questions about the way she was treated by her male colleagues. However, over the course of the interview, Imre's presence seemed to have its advantages. From what I could tell, the couple was genuinely in a very mutually supportive relationship, and there were even times when Imre remembered instances when Adrienn had experienced discrimination due to her gender, that Adrienn herself had shrugged off and forgotten about. As far as I could tell, I didn't sense that Adrienn had any hesitation speaking in front of her husband, and her comments about their working relationship sounded very sincere. However, it is impossible for me to know what (if anything) she may have said differently in his absence, so it is still necessary to take this into account as a source of potential bias.

3.3 My personal standpoint

My own location with regards to my informants made interviewing at once easier and more difficult. I am not a neutral observer by any means in this research. I chose to do this project in the first place out of a desire to explore the social and institutional factors that may explain the lack of women in mathematics. Thus, the questions I asked, and the answers I looked for, in these interviews look to explain how gender inequality in the mathematical sciences is a product of social factors. Essentially, one of my first and perhaps most natural biases is that I approach this issue from a sociological perspective, and choose to overlook explanations that invoke the respective biologies of men and women, even if they come from the informants themselves. Additionally, I approach this issue by considering how it fits into larger scheme of gender discrimination in science and other male dominated workplaces. Again, this will be reflected in the way I analyze these interviews, despite the fact that not all of my informants considered that gender plays a significant role in their professional lives.

I also approach this issue as a woman who was once in mathematics herself. This position allows me both to connect well with and relate to my informants experiences, for the most part, as well as be in a position to ask about the more technical aspects about the work they do. However, this could be a blessing and a curse - for every detail that I have insight into due to my knowledge of the field, there could be one that I miss due to my lack of critical distance precisely because of that knowledge. Throughout the course of my analysis, I have tried to remember that despite the fact that I share a common disciplinary background with my informants, their experiences need not mirror my own, and their testimonies should be analyzed as legitimate perspectives even if they differ from mine.

3.4. Possible Limitations

One of the ironies in interviewing female mathematicians about the challenges they have faced over the course of their careers is that you end up interviewing only those who managed to surmount these challenges to get to where they are, or who happened to be in `lucky' (by their own admission) circumstances that allowed them to circumvent obstacles that many other women faced. As I interviewed these women, it became clear that they were the exceptions, and not the rule. Most women (and many men) who began the path to becoming mathematicians dropped out along the way, which means that analyzing these interviews involved not just examining the issues they faced, but also understanding what issues they didn't face. The conclusions I draw about challenges that women face in the mathematical sciences are not only based on stories of difficulties that these women faced, but also on stories of how they avoided hurdles that other women often met.

Chapter Four: A short history of the mathematical community in Hungary

Much of the literature that was discussed in the previous section was based on studies done in North America and Europe. How can we tie these ideas to the Hungarian mathematical community specifically? This section outlines some key moments in the history and formation of the community of Hungarian mathematicians, and the institutions that link them together.

Hungarian mathematics' entrance on the world stage is a fairly recent event in the history of mathematics. The first internationally renowned Hungarian mathematician, Janos Bolyai, lived in the early 19th century, but his work (which revolutionized the field of non-Euclidean geometry) was only appreciated at home and abroad a few years after his death in 1860.[32] The acknowledgement of Bolyai's significant contributions to mathematics came at the same time as an important historical event – Hungary's *Ausgleich* with the Austrian Emperor Franz Joseph, which brought significant economic autonomy to the Hungarians within the Austro-Hungarian Empire.[33] This pact was followed by a rise of a strong middle class, which was accompanied by the creation of many universities, and elite gimnáziums, which led to progressively strong mathematics education. Additionally, in 1867, Hungarian minorities, most notably Jews, were granted equal civil rights, and could enter schools and universities as both students and professors in large numbers.

[32] Hersh, Reuben and John-Steiner, Vera, 1993, "A Visit to Hungarian Mathematics", *The Mathematical Intelligencer*, Volume 15, (2), pp. 13-26.
[33] Hersh, Reuben and John-Steiner, Vera, 1993.

Academia, and in particular science and mathematics (due to the recent success of Bolyai), earned a great deal of prestige in late 19th century Hungary. Tibor Frank notes that:

"Pursuing scientific professions, particularly mathematics, secured a much-desired social position for sons of Jewish-Hungarian families, who longed not only for emancipation, but also for full equality in terms of social status and psychological comfort. Thus, in many middle class Jewish families, at least one of the sons was directed into pursuing a career in academe."[34]

At the same time, a new set of elite secondary schools were being developed in Hungary to serve the emerging upper-middle class. Mór Karman was an expert on pedagogy who imported the German *Gymnasium* system into Hungary, and became the first director of a leading teacher training university founded in 1872, which trained teachers in the German tradition. Graduates of this university were very well trained in mathematics, and continued to publish papers regularly even as high school teachers. The gimnáziums were originally only for males, but in 1896, the first gimnázium for women was opened.

A major factor that influenced the rise of mathematical expertise in Hungary came at the behest of Loránd Eötvös, a renowned physicist who became the Minister of Education in 1894. As early as 1885, Eötvös created an a small informal network of university professors, high school teachers and gifted students to engage in open problems in mathematics and physics. This circle expanded to about 300 members (including three

[34] Frank, Tibor, 2007, "The Social Construction of Hungarian Genius (1867-1930)", background paper commissioned for the Princeton symposium *Budapest: The Golden Years – Early Twentieth Century Mathematics Education in Budapest and Lessons for Today*.

women) in 1891, when it came to be known as the Society of Mathematics and Physics.[35] Three years later, in 1894, this society established two institutions that continue to exist even today – the Eötvös competition, which is a yearly problem-solving competition for high school students, and *Középiskolai Matematikai Lapok* (KöMaL), which is a monthly mathematics journal for high school students. Since then, a number of secondary school competitions have been established to find mathematical talent at a young age, and the winners of these competitions as well as their teachers were reported directly to the Ministry of Education to be recognized for their achievements. Many prominent Hungarian mathematicians were winners or runners up of these prizes during their high school years.

KöMaL was intended to serve as a way to practice for mathematical competitions, and included a number of tricky problems that often required no more than high school mathematical knowledge to solve. When interviewed about her experience with KöMal, Agnes Berger (1916-2002), a Hungarian émigrée to the United States who was a statistics professor at Columbia, said the following:

"The paper came once a month. It had problems grouped according to difficulty. The solutions were published in the following way: everybody who sent in a correct solution were listed by name, and the best solution or solutions were printed. So here you were taught right away to value not only the solution, but the best solution, the most beautiful solution… It was a tremendous entertainment."[36]

Many mathematicians, including the ones interviewed for this project, cited KöMaL as a foundational part of their mathematical development. While many famous Hungarian mathematicians were competition winners, not all did their best work under competitive

[35] Frank, Tibor, 2007.
[36] Hersh, Reuben and John-Steiner, Vera, 1993.

settings and time pressure, and so much young mathematical talent was discovered among students who made frequent contributions to KöMaL. Paul Erdos, one of the most renowned mathematicians to come from Hungary, famously did not do well in the secondary school competitions. Nevertheless, he frequently appeared in KöMaL, and attributed the development of his own problem solving skills to the existence of that journal.[37]

The period after World War I, however, saw some fairly fundamental changes befall Hungary, and ergo, the mathematical community. The Treaty of Trianon splintered the country, which led to a period of instability during which a group of Communists came to power, under Béla Kun. They were in power for only four months before the White Terror began under Miklos Horthy, who led a group of right-wing armed forces to take over the capital, and violently purge out communist supporters and political liberals. Much of this violence was also directed at Jews, making Hungary an unsafe place for liberal Jewish intellectuals during this time. Horthy went on to establish quotas in the educational system, and wished to limit the number of Jews in schools and universities to 6% of the student body. It became almost impossible for Jewish academics to obtain professorships or teaching positions.[38] This led many mathematicians of Jewish origin to leave Hungary during the inter-war period, particularly as the threat of Nazism loomed large. Before their eventual departure from Budapest, a few of those unemployed mathematicians, led by Paul Erdos, met informally by the Anonymous statue in

[37] Hersh, Reuben and John-Steiner, Vera, 1993.
[38] Hersh, Reuben and John-Steiner, Vera, 1993.

Városliget to do research in discrete mathematics, which began the strong tradition of research in graph theory and combinatorics that continues in Hungary today.[39]

The next major change in the history of Hungarian mathematics came after World War II, when Hungary entered the socialist era. Before this time, Hungarian education was openly class-based – students were required to complete four years of elementary school, which was free, but schooling after that point was not. The vast majority of children either joined the labor force or did two extra years of vocational training at the age of ten, and about 18% joined a four-year "polgári iskola" or bourgeois school where they were trained towards lower white-collar occupations.[40] Only 7% of the population attended the eight-year gimnáziums (from which you could advance to university education) and with very few exceptions, this 7% represented mostly male students who were descendants of the social elite.[41]

During the 1920s and 1940s, education was greatly expanded, as there was a demand for educated women during the wartime period. The education system, particularly primary education, was expanded considerably, and as the years progressed, the gender gap in education became much smaller. In 1949, all schools were nationalized, and the period of compulsory education was lengthened to eight years, and the gender gap in average number of years of education was virtually closed in a few years after that.[42]

[39] *N is a Number: A Portrait of Paul Erdos*. Dir. George Paul Csicsery, 1993.
[40] Szelényi, Szonja, 1998, *Equality By Design: The Grand Experiment of Destratification in Socialist Hungary*, Stanford University Press, Stanford, pp. 22-23.
[41] Szelényi, Szonja, 1998, p. 23.
[42] Szelényi, Szonja, 1998, p. 32.

Finally, the improved access to education led to the influx of women in the labor force. After 1949, the women's participation in the labor force swelled from 60% to 93%. By the end of the socialist period, men and women were equally represented in managerial positions, while women were indeed overrepresented relative to men in the professional sector (which included intellectuals).[43] While this was not true of mathematics in particular (there were still far more male mathematicians than female), women mathematicians in Hungary arguably had an easier time finding employment between 1930 and 1960 than women in the US. It was quite uncommon (and sometimes actively discouraged) for women to occupy tenured professorships in mathematics in research universities until the mid-'50s and '60s in the United States[44]- they typically occupied teaching positions at undergraduate women's colleges.

In 1950, the Alfred Rényi Institute was formed as a division of the Hungarian Academy of Sciences, and functioned as a research institute that supported mathematicians, provided grants for travel, and hosted seminars. It remains one of the important centers of mathematics research today in Hungary. In 1962, Fazékas Gimnázium began its intensive mathematics program for secondary school students, which began by recruiting mathematical talent among Hungarian youth, by their results in mathematical contests, their contributions to KöMaL, or even by recommendation from teachers of talented students. The Hungarian national team to the International Mathematical Olympiad regularly features students from this program, which has graduated several gold-

[43] Szelényi, Szonja, 1998, pp. 53-55
[44] [44] Henrion, Claudia, 1997.

medalists, and many of the mathematicians working in Budapest today. It was not the first such program to exist in Hungary, but it is one of the most prominent ones of its kind that still functions today, and its impact on the mathematical community in Hungary is widely cited. For instance, out of the thirteen professors at ELTE's Department of Algebra, eight graduated from Fazékas, and the remaining five professors include a few who attended high school before the program at Fazékas even began.

During the Soviet era, mathematics in Hungary was greatly affected by the extent to which mathematicians could move across borders. Miklós,[45] who is a prominent member of the Rényi Institute, commented on the importance of travel and cross-national communication among mathematicians. Many leading mathematicians had moved abroad in the early 20th century, but attempted to keep ties with mathematicians in Hungary. Similarly, such travel on the part of Hungarian mathematicians were necessary to keep research relevant on the world stage, and as mathematics grew to be more collaborative over the course of the 20th century, the importance of maintaining these ties grew. Until the '60s and early '70s, it was difficult for Hungarian mathematicians to travel freely outside of the Soviet Bloc, and Miklós remembers mathematicians who were unable to leave the country to take up fellowships in West Germany. As the borders became more permeable in the 1970s and '80s, Miklós found that the change of system during 1989 did not have a very significant impact on the production of mathematics (though the finances of the Rényi Institute came under question when the post-Soviet Hungarian economy began to struggle). Rather, the community changed as the borders became more open in

[45] Name changed to protect privacy.

the ‘70s and ‘80s, with more promising young talent choosing to go abroad to pursue PhDs after completing their university degree. While it used to be quite competitive to enter mathematics programs at universities like ELTE, the expansion of higher education in Hungary I the 1990s allowed for many more students to enter the field. After the Bologna Process came under effect five years ago, with the five-year mathematics degree being broken down into separate BSc and MSc degrees, Miklós observed that promising students left even earlier, to pursue MSc degrees outside Hungary, constituting somewhat of a brain drain to the Hungarian mathematical community.

Finally, both Miklós and Adrienn commented upon the community of graduate students. Miklós claimed that the selection process for the PhD was much less competitive, despite the requirements for the PhD being fairly high. He noted that especially in recent years, PhD students in mathematics were largely self-selecting, and most who showed interest were able to pursue advanced degrees at one of the four institutes in Hungary that offered Hungarian-accredited PhDs in mathematics – ELTE, the Technical University of Budapest, University of Szeged and University of Debrecen[46]. Adrienn also corroborated this notion of PhD students being self-selecting, and said that she has yet to turn away a student who wanted to work with her.

[46] CEU’s doctoral program in mathematics is not Hungarian accredited, and also is much more competitive to enter.

Chapter Five: Making it in Budapest's mathematical community

This section is split into three subsections, each of which focuses on a different type of challenge that women mathematicians experience in Hungary, based on the interviews. I first examine the barriers involved in maintaining a family with working, and then move on to the ways in which gender stereotypes are constructed in mathematics. Finally, I end this section with a consideration of the effects of tokenism and isolation on women mathematicians.

5.1 Mathematics as a masculine endeavor

The literature presented in Chapter 2 focused on the many ways that mathematics is viewed and portrayed as a masculine endeavor, and from my interviews, I found that this image is still pervasive. Adrienn and Izabella's testimonies provided fascinating insights into the way mathematics is gendered by society, and how women mathematicians reconcile their gender with their presence in a stereotypically masculine field.

When Adrienn was asked whether her parents accepted her being a mathematician, she said:

"...my mother was very happy. And she was from Transylvania, and in Transylvania, the Szekelys had a tradition that in a family, if there was no boy, only girls, then the first girl was treated like a boy. Taught, and so on. ... I had a sister. And then my mother said okay, I am promoted to be a boy."

This was an interesting instance of how mathematics is subtly perceived as a male domain. Adrienn's mother's support came from the insistence that her child be encouraged to do something 'boy-like', i.e. mathematics. Adrienn mentioned this in a positive light, however, and was eager to say how well both her parents supported her when she demonstrated an interest in mathematics. What is particularly fascinating is that the support that was granted to Adrienn was the permission to do something stereotypically masculine while still being a woman, or being 'promoted' to being a boy, without consequences. Despite not challenging mathematics as a male endeavor, Adrienn found a way to get around the 'double-bind' illustrated in Chapter 2 – she accepted the symbolic promotion to being like a boy, and thus felt comfortable doing mathematics from a young age. This support was important to Adrienn, even if it reinforced stereotypes. She is perfectly aware, for instance, that there are plenty of negative associations surrounding her gender and her profession. She says:

"…we do have many men who are very competitive colleagues. And sometimes, when they feel that I am better than them, then they say that, "this *woman* solved this!""

This is another manifestation of the presumed masculinity of mathematics – the indignant male colleague who thinks that if a woman is better than him at mathematics, it calls into question his own masculinity. This is comparable to the rhetoric used in other male domains, like sports, where being less competent than a woman signifies emasculation.

It was interesting to note, however, that Adrienn could not immediately any specific incident, when asked whether her colleagues ever treated her differently because she was a woman. She recalled this particular episode only after her husband Imre instantly placed his finger on it as an example. Adrienn was more likely to brush these episodes off, but Imre seemed to be much more chagrined about them. Imre was not only married to Adrienn – they were each other's primary collaborators, and Adrienn repeatedly mentions him as being one of her strongest supporters.

“I feel very lucky, that the people I love value me or admire me for my mathematical ability, I know there are many, many men who would say that that's a freak, to be a mathematician, and a girl. Especially if they are not mathematicians. So that's why I said that I feel very lucky."

Having the support of those who respect her for her mathematical ability in this manner continues to help Adrienn resolve the double-bind, as she feels like she has a group of people surrounding her who celebrate, rather than denigrate her mathematical abilities. When I attempted to ask Adrienn more about the nature of the support, Imre interjected and proceeded to tell the story of how he first became enamored by her. The story unexpectedly revealed the way in which gender stereotypes were constructed.

“I had to tell my friends, after spending lots of times with these girls, that I cannot interact with the girls. They are not like boys. They don't think like boys. They are just like plants, or something. And I didn't mean it as a criticism. It was an experience of not being able to share ideas. If I started to talk about something which really interested me, then next time I heard from my girlfriend, that I was telling her about voodoo magic. Which is something I wasn't talking about. So as soon as I started to talk about scientific ideas, about how the Earth moves around in the solar system, when the axis is tilted... I started to tell these tales, and they just ruled out the information, and my impression was that that's the way girls are. But no, [Adrienn] is different.”

This ended up being a classic description of how the lack of interest in science among some women is extrapolated to mean that women in general are incapable of science. It is hard to imagine that if Imre met boys who had a complete lack of interest in science, he would assume that men could not do science. Moreover, he mentioned that the girls he met did not ‘think like the boys’ – implying that ‘the way boys think’ is the standard for what it takes to accomplish science.

It is important to note here that Imre is actually extremely well-intentioned – he was aware of overt instances of discrimination when they occurred, and Adrienn repeatedly (and sincerely) referred to him as a person who supported her work. However, these implicit assumptions of the masculinity of scientific inquiry were present despite Imre's good intentions, which demonstrates how culturally embedded these ideas are.

5.2 Inverting the double-bind

Like Adrienn, Izabella also met people at a young age who associated mathematics predominantly with men. However, her foray into mathematics, unlike Adrienn's, was considered inappropriate for a woman.

"...in my family, they didn't want me to be a mathematician, they said it didn't fit to a woman, and so on and so forth. They were surprised. They thought that it wasn't woman-like, or something."

Both Adrienn and Izabella were aware that their gender was often perceived to be at odds with their profession. However, when interviewed, they did not seem to outwardly experience the double-bind as a conflict. Adrienn mentioned support from her loved ones as being instrumental in feeling welcome in mathematics, but there also seemed to be another way in which both these mathematicians confronted this issue. During their interviews, they spoke about how they came to view the practice of mathematics itself as multi-faceted, with opportunities for their feminine traits to be of use in the field. For instance, Adrienn believes that nurturing and community building is something that women do better than men, and additionally claims that it is an important part of mathematics:

"...women always have to build communities, families, so women usually search compromises, listen more to the other person, they are more co-operative, and they... it is more easy for them to grow a mathematical theorem like to grow a plant. To feed, to give the food for it... and, of course, men have different traits. So they are more competitive, they can defend the group, if someone from the outside wants to get away with something that belongs to the group, or if they interfere, they can just concentrate more on one thing, and say “No, I'm not interested...", and go that way. So that's good - they complement each other. "

Adrienn accepts and even embraces these stereotypes about women and men. What she redefines, however, is what it means to do mathematics. She identifies practices in mathematics that are stereotypically feminine, and emphasizes that the co-operative and communal aspects of conducting mathematical research are part of the female domain. When asked how she got used to being one of only two girls in her advanced secondary school math program, Izabella also claimed that there are things that women are better at in mathematics, similar to the way Adrienn made her claim.

“...you must have some ability of abstraction... so sometimes a very simple way of thinking leads to a great result. You must forget about the non-important details... you must find what is really important. And sometimes men can better concentrate on those things. But also, I think also, you must have intuition, an intuition for that, and in this, women are better. So I try to learn that concentration ability from men, but I try to use my intuition ability as well."

Izabella identifies ‘women’s intuition’ as a trait that she believes advantages women more in mathematics, and similarly carves out an aspect of mathematics that she believes is feminine. Framing their work in such a way allows both Adrienn and Izabella to appropriate mathematics as a discipline for women as well as men. While they accepted the stereotypes that existed about women - that they were nurturing, maternal, intuitive, and so on, they chose instead to insist that these qualities actively helped them do mathematics, thereby asserting that their field does not need to be stereotypically masculine.

5.3 Combating isolation, and forming mathematical communities

One of the constant themes that emerged in all four interviews was the importance of having a strong, supportive community while doing mathematics. This is in line with much of the research that was summarized in Chapter 2, which suggested that women are more likely to stay in mathematics if they find a community of colleagues that they feel like they 'belong' with, that allows them to create a positive identity for themselves as mathematicians. The clearest examples of this form of community building are seen in Rózsa and Adrienn's testimonies.

Rózsa and Adrienn both grew up in Budapest, and were deeply involved in mathematics from their school years onwards. Adrienn fondly recalls her secondary school years spent in an intensive math program:

"I went to a secondary school that was specialized in mathematics. That was the first such class. It was for 10 boys and 10 girls. And we had special teachers, very, very good special teachers. And we were learning university mathematics already in secondary school. And of course, we worked together- everyone in our class was somehow talented in mathematics, and that was very good. We... and the best thing was we formed a very tight community - we were friends with each other and family for each other. That was a great experience."

The program she mentions is the one at Fazékas Gimnázium, discussed earlier in Chapter 4. She was in the first cohort of students to attend the program, along with several other mathematicians who ended up becoming very prominent. I registered a fair amount of surprise during the interview that there were an equal number of boys and girls in the program. She explained that in the first few years, the balance changed slightly, to nine girls and twelve boys, but that it was basically even. Presumably, since the program was in its nascent stages, the organizers attempted to create an even gender balance. Many students were selected on the basis of their performance in mathematics contests, but there were several, including Adrienn, who were selected based on recommendations from schoolteachers. She was incredibly genuine and nostalgic when describing her experience at the gimnázium, and she mentioned that she still knows and works with the people who attended this program with her.

Rózsa also described a similar experience at her university, which at the time only had one mathematics program, which was the teacher of mathematics and physics program. It was very intensive and challenging, and had roughly the same number of men and women. She says of the experience:

"It was very good. Very, very good. Even now, I have some good friends... it was very good. We did work together, and the competitions... it was not a competition in the bad sense, but it was a very very good atmosphere, I would say. Among students, and among teachers as well. "

Rözsa, like Adrienn, highlighted the extent that she worked together with her colleagues, and mentioned that this was an important part of her mathematical development. Both Adrienn and Rózsa mentioned that these experiences were formative in developing their long term interest in mathematics, and that their networks of collaboration still occasionally included people from these programs, despite the fact that they took place many years ago. Of the four mathematicians, Adrienn and Rózsa also appeared to face the fewest challenges with regards to their gender, and truly felt respected by their colleagues. They both cited the importance of a supportive and active community of mathematicians as instrumental to them feeling that their gender did not matter while doing mathematics.

While Adrienn and Rózsa did not actively point to the fact that they studied mathematics in fairly gender balanced environments as being important to them, I am inclined to believe that this played a role in helping them form strong mathematical communities, where they were not actively judged based on their gender. Izabella and Márta, for instance, faced more challenges when attempting to join a mathematical community, and the stories of their mathematical development showed that they went through difficult periods of isolation during their education.

Márta's journey to find a community in mathematics hit several bumps along the way, and this was clear in the way she described her university education in Budapest. Her interview was harder to unpack than the others; her initial reluctance to speak freely meant that I had to take many cues from her body language and demeanor, and not immediately take what she said at face value. Initially, she insisted that she had always been treated equally by her classmates and colleagues, though she sounded defensive when she said this.

She mentioned that the first degree she obtained was the teacher of mathematics degree. Since she was working exclusively as a research mathematician now, I asked her what made her want to do this degree, as opposed to the research mathematics degree. At this point, she looked uncomfortable, and asked that I turn the recorder off. She then said:

“I actually applied to the research mathematics group, but after one and a half years, it was very difficult. So I switched to the teacher of mathematics course. There is a big difference between mathematics and teacher of mathematics courses. But I could still visit classes for the mathematics course. [Pause]. But it doesn't matter now. It was so long ago."

It seemed clear from her voice and her demeanor, however, that it still did matter. It took some time to coax out the reasons for which she switched programs. Later in the interview, I asked her if her university encouraged students to compete against one another, and she laughed and emphatically responded that it did. She mentioned overhearing professors talking about individual students, and judging them harshly for their incompetence. She remembered thinking "So what does it matter? They're human…" Students would, as a result, strive to outperform one another, and this particularly affected women. Márta noted:

"The other women at the university... the girls were thinking that they were not as good, they were comparing themselves with the boys."

It seems relevant to mention here that four out of the thirty-five students in the research mathematics program were women, and the onus to was on them to prove their worth. This situation illustrates how tokenism plays out in male-dominated fields - the token group of girls felt the need to judge their worth as female mathematicians against men, and failure to 'win' the competition led to the conclusion that this had to do with them being women, or led others to the conclusion that women were not as competent in mathematics. The competitive environment seemed to be fostered by the professors' harsh judgment of the students, but the competition played itself out as 'boys versus girls' to a certain extent, due to the clear disparity in numbers.

The teacher of mathematics program that Márta switched to had roughly the same number of women and men, with possibly more women. She mentioned that this program was less demanding, but she still took many courses from the research mathematics track, and attended seminars at the Rényi Institute. Interestingly enough, she went on to do original research in mathematical logic for her final thesis (which was above and beyond what was required for the teacher of mathematics degree) and proceeded to begin a PhD. She was a clearly competent mathematician, yet the competitive environment in the research mathematics program was isolating enough for her to switch into the teacher of mathematics program. Competition is the opposite of co-operation and community building – it requires you to define yourself against other people, which isolates you from them. If you are one of the few women in a group that consists mostly of men, in a male-dominated field, there is much more pressure to prove your competence as a woman. Yet often, as LaFollette's and Rosser's research suggests, proving your competence as a woman often requires performing above and beyond most men, and failing to do so automatically implies inferiority. As a result, despite Márta's insistence that there was no difference in experience between men and women in mathematics, I am inclined to believe that a male-dominated competitive environment caused her to call into question her substantial competence in mathematics.

She herself eventually came around to acknowledge this. I asked her if she used to be competitive. She smiled and said "I was competitive at the university. The group here changed me." The 'group' referenced here is her current research group at her institute, which coincidentally includes Adrienn and Imre. She said this quite happily and sincerely, and I was very moved to see this, as it was a clear departure from the discomfort she had earlier while discussing how competitive her university was. It transpired that despite being in the teacher of mathematics program, her thesis contained original research in pure mathematics, which she was encouraged to do by her advisor (who incidentally was her only female mathematics professor). It was above and beyond what was required by her program. She worked on this thesis with Adrienn and Imre, who she had met through the seminars at the institute. Her advisor, as well as Adrienn and Imre, encouraged her to do research with her current research group, and work towards a PhD. It was here that Izabella finally found her community. While she claimed that the research mathematics track at her university was too difficult for her, she said that she was always very confident that she could handle her PhD, despite the fact that the mathematics involved was of comparable (or even greater) difficulty.

Márta had a much better experience as a mathematician once she found a more supportive work environment, which fostered collaboration. Towards the end of Márta's interview, I asked her what advice she would give to someone who wanted to become a mathematician. Her immediate response was:

“Best thing is to find a group, and to work together with other mathematicians. [Thoughtful pause]. The difference between our group and other groups, or maybe it is not so different, I don't know, is that there is no competition in our group."

Finding this community proved to make a huge difference in the way Márta experienced professional mathematical life, to the extent that she prioritized it as the way one could really achieve professional success in the field. The ‘lack of competition' that she refers to is in stark contrast with her experience at university, which required her to prove herself in a competitive environment on a regular basis. Adrienn independently commented on the type of research environment that she attempted to create among her students and fellow researchers:

"Competition... has negative and positive sides. So I think we more or less dealt with the negative part of it because we always taught our students that we work as a group. So we don't compete in the way that I want to be better than the other person, or that I keep myself information so that I get the advanced position. So our policy is that we work as a group, we are open, information is open, it doesn't matter who is cleverer, who had the idea first, because the group, the interesting thing is that as a group, we find something interesting, so the thing is that we discover something interesting, or something beautiful. So co-operation is necessary."

It surprised me initially that Adrienn had the luxury of accepting everyone who wanted to work with her as a student. It transpired that this was due to the shrinking group of students who chose to pursue their studies in Budapest, now that it was much easier to go abroad for a PhD. As a result, Adrienn could welcome those who came to their group with an interest in pursuing research with them, and as noted in Chapter 4, her group of PhD students ended up being quite self-selecting. This is an area where the Hungarian mathematical community differs significantly from the U.S. – the competition to get into graduate programs, particularly the top graduate programs, in the United States is quite fierce, and the programs that a student is accepted to is seen as a mark of their abilities in mathematics. Adrienn and Imre, however, had the luxury of creating a tight-knit, co-operative community of mathematicians, and Márta undoubtedly benefited from their supervision. After Márta completed her PhD, she obtained a position at the institute Adrienn and Imre are at, and is now their colleague in addition to being their collaborator.

Isolation and tokenism can be experienced in different ways. Izabella also experienced a certain amount of isolation during her education. She was one of only two girls in her secondary school math program, and she admitted that this was challenging. Moreover, she frankly admitted to the isolation she felt when she left the countryside and joined a university in Budapest.

"Yes, most of them were men, and what was very disturbing for me was that most of them came from Fazékas Gimnázium, and other special classes, and I knew only two or three students from my school. So in the beginning, it was hard for me, because I didn't know majority of the people, and that was the painful beginning... so the first two years were very hard in fact. But it was a good education. I am glad I got through that phase."

This type of informal isolation is frequently experienced by token members of a group, where it is difficult to break into dominant social structures. In this case, Izabella was not only experiencing being an outsider as a woman, but also as a person from the countryside, by entering a university filled with students who went to school together in Budapest. Although she goes on to describe the few friends that she eventually made in class, and worked on mathematics with, she acknowledges that the time she spent in isolation was a big challenge. She emphasized that once she did find people to work with, her experience of university life improved tremendously. Out of the four mathematicians interviewed, Izabella was the most likely to work on her research alone. Yet she mentioned that she still informally talks to several mathematicians about her work, including Rózsa, and her former PhD advisor, and brainstorms ideas with them when she hits a wall.

5.4 The importance of location

The communities that Rózsa and Adrienn experienced during their formative mathematical years not only gave them the feeling of belonging in mathematics; they gave them people to work with for the rest of their lives. Since both of them were born and raised in Budapest, the people they went to secondary school with invariably also became their colleagues, and it was natural to continue many of the working relationships that were forged in the past. Adrienn mentions that her classmates at Fazékas still get together from time to time, both professionally and socially. Rózsa specifically noted that this was a part of growing up and continuing to live in a small country - the community of mathematicians was quite small and everyone knew each other for years, and mutual ties of respect that were created at a young age were reproduced as the community aged. Izabella had the same experience, and described this in more detail:

"…there was a boy who was the most clever, and even now he teaches at Eötvös University, and… even now, we frequently consult each other. So sometimes I feel that practically nothing changed, because I see that I am surrounded by practically the same people. So if I want to ask somebody a question, I ask the same people. And so now they are partly my colleagues. I work in different places, but I do research and projects with practically the same people. And it is small country, and not very many mathematicians, so you see the same people."

Being in a small country, which had it's strongest math programs concentrated within a small group of secondary schools and universities meant that mathematicians that ended up working in Budapest often knew each other, and since there was relatively little movement of mathematicians among different cities and universities within Hungary, communities that were forged early on continued to stay together. This is a departure from the way mathematical communities form in the United States – people tend to move around much more, and often end up in wildly different cities for their college degree, their graduate degree and their first teaching appointment. While some research groups stay together despite these moves and distances, often, mathematicians need to redevelop their immediate community at every stage in the process. This does not automatically mean that these communities are impossible to form, or find again. However, the linear process through which one becomes a mathematician in Hungary often provides the continued existence of a community as one moves into the profession.

A chief difference that is seen between the theoretical literature that this project draws on (which is largely centered around American academia) and the realities of the Hungarian mathematical community is the moment of community formation. Claudia Henrion notes that many women mathematicians in the U.S. found their communities in graduate school, which was the time that they first began to do serious research with other people, and identified themselves as mathematicians. In Hungary, my observation has been that this identity is formed earlier, often during secondary school. Attendance of advanced secondary school mathematics programs, participation in contests and submissions to KöMaL are determinants of the mathematical in-group in high schools. The existence of these programs do encourage students to excel in and pursue mathematics from a young age onwards, but perhaps also determine fairly early on which students would go on to become mathematicians, and which students would not. Admittedly, attending an elite secondary school program is not a requirement to becoming a successful mathematician. However, as Rózsa and Adrienn suggested, they can be of tremendous help, both in developing mathematical ability as well as a network of collaborators. As noted in Chapter 4, a large number of current mathematicians attended such programs, and Izabella and Márta's testimonies suggested that breaking into these communities that have already formed can often be difficult and isolating. With every tightly knit community comes a group that is outside it, and it seems that the outside is determined at an earlier stage in Hungary.

5.5 Family circumstances

When asked what the largest factor that drew women away from mathematics was, Adrienn, Rózsa and Izabella all mentioned that working as a mathematician while raising a family posed a great challenge. Adrienn and Márta never had children of their own. Imre had children with his first wife, and although Adrienn shares a good relationship with them, she was never their primary caregiver (they lived with Imre's former wife).

Rózsa mentioned that although she had two sons, her parents were very supportive, and helped her raised them. When asked what challenges women faced in mathematics, the first factor she mentioned was family responsibilities.

"…from a family point of view, no doubt, in some periods, you have family and children, and then somebody has to stop and then it is not so easy to get back again. I was very lucky, because my parents helped, and as I told you, I have two sons, and when they were born, my parents really helped when they were small. So I never really stopped being at the university. Now in Hungary, there is a possibility to be away from work for 2-3 years, as you know. It did not exist at that time, it was 3 or 4 months, I don't know how long it was, but my parents helped very much. And without that, it wouldn't have been possible to do that. Again, in a small country it is different. I was born in Budapest, my parents, my family, almost everybody lived in Budapest... of course I traveled, because this belongs to the profession, somehow, but even then, when I traveled, went to conferences, I was able to leave my children at home, and this really makes a difference."

Rózsa certainly considered herself to be an exception in this regard, and coincidentally attributed her lucky circumstances to living in a small country, with her family close by. Again, this is a departure from much of the literature on this topic, which was focused on the United States. Rosser examines the difficulties that women scientists in the U.S. faced while balancing work and family, and it seemed very rare indeed that women in the

United States could rely on their family for support. Part of this was the expectation that children be independent from their parents once they left home, but another large factor was the fact that scientists in the United States very rarely lived in the same place they grew up, or near their parents.

Out of the four women I interviewed, Izabella was the only one who claimed to have undergone the challenges of maintaining a family while being a mathematician. When asked whether she was married, she said:

“I divorced a while ago. My husband was a mathematician. We went to America for a while, you know - I was nobody there. I was just there with my son. It would have been hard for me to get a job. I could get a job, but I couldn't have continued my research with these people, on this topic. That was the cause for separating."

Izabella thus had to make a difficult choice between staying with her research and staying with her husband, and she chose to stay with mathematics. She went on to admit that her husband did not want her to work, and when asked why, she said:

“Maybe because of the Hungarian tradition. For example, my mother didn't work and his mother didn't work. But this was another age… still he had the idea that women couldn't work, and should stay at home.”

This was rather surprising to me at the time, because this was in the 1980s, after many years of communism, during which it became quite natural for women to work. She went on to say that after her divorce, her mother helped her raise her son while she pursued her candidate's degree, which she admitted was very challenging to accomplish, with her dual commitments as a researcher and a mother. Izabella's mother died soon after, and so Izabella left the research institute she was at for a teaching position at a university, stating that the university had more flexible hours and summers off so that she could be with her son.

Despite the fact that Izabella was the only informant I interviewed who faced these challenges, I am inclined to think that her situation is not unusual - in fact, both Adrienn and Rózsa mentioned family commitments as one of the main things that drew many women away from mathematics. Izabella’s situation seemed to fall into the same pattern that much of the literature on balancing motherhood and employment suggests – many institutions made it difficult to raise a child while pursuing a career, and the resulting ‘time bind’ often caused women to hit a glass ceiling.

What was more revealing, however, was the way Adrienn and Rózsa characterized a particular challenge that mathematicians in particular faced with regard to raising children. They independently pointed to the fact that occasionally, doing mathematics involves voluntarily withdrawing from the world for sometime, and the ability to do that is a privilege, as it involves abdicating responsibility towards other people, especially children. Both these mathematicians made this observation in very similar ways.

From Adrienn's interview:

“It is difficult, by the way, to be a mathematician, a woman mathematician - it does have a difficulty... The thing is that, if you are thinking very hard on a problem, then in a way, you leave this world. You are living in the world of the abstract ideas. You become vulnerable, absent minded, you do not know what happens around you, you become a little bit asocial. You have to have the courage, or the willingness, to leave the world for a while. I mean, consciously. And if you are very much involved in a family, perhaps you don't have- you cannot do that, maybe.”

From Rózsa's interview:

"...maybe one has to be a bit introverted. Because sometimes in mathematics you need to think over the things, you really must sit alone in the corner of the dark room. It is not necessary, but if you wanted to solve a problem, you feel like you need something from inside... But, I don't know - maybe having a baby or something like that already indicates, that with children, you cannot be very introverted you know?"

What was particularly interesting about this characterization of the difficulty of being a mother while being a mathematician was that it drew attention to the mental aspect of mathematical labor, rather than the physical. Much of the literature that exists on the topic of women's struggle to balance work life and home life focuses on the different places that women physically split their time between - i.e. the office and home. A career in a discipline like mathematics, which requires tremendous mental focus (as reported by all four informants), requires not just a commitment to physically be at a workplace, but also a commitment to mentally forgetting about everything else but mathematics for extended periods of time. In a field like mathematics, which requires an unencumbered mind, the fact that familial responsibilities are often placed solely on women could make a difference in how much mathematical research they are able to produce. Additionally, as LaFollette notes, women scientists are not exempted from their maternal responsibilities when they choose to enter science, while male scientists are often praised for their absent-mindedness and the time they spend focused on their work – they are seen as committing their lives to a higher purpose when they ignore familial responsibilities for the sake of science. Balancing a life as a scientist and as a mother is still seen as a contradiction, as the single-minded attention and devotion that is seen as a requirement of the field is often a luxury that mostly men can afford, due to the fact that they are more often relinquished of family duties. The expected level of dedication and productivity in science and mathematics is also based historically on men who have had this luxury of time, and being able to meet these demands as a woman who has greater commitments to family rearing is often difficult.

Chapter Six: Conclusion

The interviews conducted demonstrate that working as a woman in a male dominated field such as mathematics is indeed difficult, but that there are ways in which these barriers can be overcome. The stories of these women show that while mathematics is indeed still dominated by men, and considered a male endeavor, there can be institutional ways that can help women transcend token status and help them ascend to full members of the mathematical community. The overwhelming consensus of the informants was that the reason that they kept going in mathematics was because of the sense of community they felt within it. In Budapest particularly, it seems like this community is created at a young age, and the way women (or even men) identify with mathematics at a young age is likely to have an effect on how they view themselves as part of it for the rest of their lives.

Given the level of significance that these early forms of community building have – it is clear that one way women can be encouraged to enter mathematics in Budapest is by providing them adequate support at the secondary school level and encouragement to apply for admission at secondary school mathematics programs. These programs, as well as contributing to high school journals and participating in contexts, are gatekeepers to the mathematical community in Budapest.

The next area that suggests action is the support system that exists for women mathematicians who wish to start a family while pursuing their careers. My informants, as well previous research in the area, suggest that a large factor in the relative absence of women mathematicians in Budapest is the difficulty that women face in balancing their family with their work.

This research however, focuses on showing primarily how the women in Hungary ‘made it in the mathematical community’, and does not tell the story of the thousands that did not make it. Perhaps this could be a suitable research question to pursue in the future.

Appendix

This is the list of questions asked at the interviews. Typically, the questions in boldface were asked directly at first, and then I would try and find out the answer to each sub question, if the interviewee did not immediately contribute that information.

1) **What made you want to be a mathematician?**
-What age did you first want to be a mathematician?
-Who or what were your influences, if any?

2) **What kind of family did you grow up in?**
-Was your mathematical talent encouraged at home?

3) **What do you remember about your mathematics education in primary and secondary school?**
-Was your mathematical talent encouraged at school?

4) **What do you remember about your undergraduate mathematics education?**
-How many women were in your class?
-How many female professors did you have?
-How were you seen by your professors and classmates?
-Did you face any challenges? If so, what were they?

5) **Why did you choose to pursue a graduate degree in mathematics?**

6) **What do you remember about your graduate mathematics education?**
-How many women were in your cohort?
-How many female professors did you have?
-How were you seen by your professors and classmates?
-What was your relationship with your adviser like?
-Did you face any challenges? If so, what were they?

7) **How would you describe your family now?**
-Do you have a spouse/partner? If yes, how does it affect your ability to pursue mathematics?
-Do you have children, or other dependents? If yes, how does being a caregiver affect your ability to pursue mathematics?

8) **How would you describe your professional life? What do you do everyday?**
-How are you viewed by your colleagues and students?
-How did you rise to your current position?
-What academic and institutional procedures did you need to go through to secure your current position?\\

9) **Do you co-author with other mathematicians? If yes, what is the experience of co-authoring like?**
-How many people have you co-authored with?
-How do you find co-authors?
-Are there any challenges that you experience in finding co-authors, or co-authoring with someone?
-How does status, or perceived status, play into creating co-authorships?\\
-What institutional factors affect co-authorships?\\
-Did you face any challenges or conflicts while co-authoring a paper? If so, what were they?

10) **What, in your opinion, makes someone a `good mathematician'? What qualities should they possess?**
-How is this categorized? Is this categorization gendered?
-How does the interviewee perceive their own relationship with mathematics?

11) Final comments, thoughts, suggestions, clarification on particular details.

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