



ISSN: 2395-7852



International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)

Volume 11, Issue 2, March 2024



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

IMPACT FACTOR: 7.583

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Women in Mathematics: An Alarming Gender Gap

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ABSTRACT: The history of mathematics shows that most of the great mathematicians from ancient times to the present have been men. Furthermore, mathematics was thought to be a male subject and was largely closed to women. Despite all the obstacles, some women managed to excel in the field of mathematics. In addition, it begs the question, why are there so few female mathematicians? Don't women know math? In this article, we tried to find answers to some of these questions. We also discuss the reasons that prevent and stifle talented young women from pursuing mathematics as a career choice.

KEYWORDS: Women Mathematician, Mathematics, Gender Disparity.

I. INTRODUCTION

Throughout the history of mathematics, mainly only the contributions of men to mathematics have been mentioned. Alma Steingart, a historian of applied mathematics at Columbia University in New York, has been quoted as saying that "mathematics is one of the worst fields for female participation." His quote is very important from ancient times to the 21st century. In 1937, Eric Temple Bell published *Men of Mathematics*, an influential collection of biographical essays reflecting on male dominance in mathematics. This book has a major impact on the younger generation. However, it also has a downside. As the title of the book suggests, female mathematicians are barely mentioned throughout the book, and this sometimes leads to frustration among women, especially younger minds. History also reveals the same phenomenon. Since ancient times, women have received little encouragement and their hunger has always been suppressed. Even today women struggle with various problems in education, society and personal life. Prof. Karen Uhlenbeck; the first woman who received the Nobel Prize; "Looking back now, I realize that I was very lucky. I was at the forefront of a generation of women who were actually able to get real jobs in academia. I've really felt like a woman in my entire career. I mean, I've never felt me as such. of the boys." Aristotle's (384-322 BC) infamous quote about women being "imperfect men" clearly describes the denial of education to women in ancient times. Women were forced to live as slaves. However, some extraordinary women overcame all obstacles and secured their place in history. In medieval Europe, women who wanted to acquire non-religious knowledge were considered bad for society [1,10]. They were often exhorted to the scriptures to purify themselves because, according to the Bible, Eve was believed to be responsible for Adam eating the forbidden fruit, which caused man's expulsion from Paradise. Their curriculum included religious reading and writing, embroidery, spinning, painting, morals, education and music. In the late Middle Ages, with the rise of universities, access to higher education benefited women, although it was limited to upper-class women. Medieval historian G. G. Coulton described that [3] "Although very few women achieved university-style education, it seems likely that more of them could read and write than men" (Beard, 1946). things are gradually changing day by day as more women participate in mathematics. However, women continue to be under represented in science and related fields, whether in college and university or in the workplace.

II. RATIONALE OF THE STUDY

Evidence shows that from ancient times women are deprived of acquiring knowledge. Sadly, women are always treated as an object. Although, some females succeeded in overcome that situation and secured a place in history. The research report shows that very little research has been carried out in analyzing the cause of the low participation of women in mathematical research. It persuaded the present researcher to raise the following issue: What is the significant contribution of a female mathematician? What is the participation rate of women in mathematics? What are the causes that prevent women from taking mathematics as their career? What are some initiatives taken by different organizations in improving their situation? In this article, we shall discuss some of these issues in detail. To find out



the answers to these questions, the present study, entitled " Women in Mathematics: A Study of the Gender Gap," is designed with the following objectives.

III. OBJECTIVES OF THE STUDY

Literature shows that the participation of women in mathematical research is comparatively low than that of males, and there are very few women mathematicians. Therefore, the objectives of our study are the following:

1. To study the life of some women mathematicians from the ancient to the modern age.
2. To find out the participation rate of women in mathematics.
3. To analyze the causes which prevent women from taking mathematics as their career.
4. To study various initiatives for the improvement in women's participation in mathematical research.

IV. WOMEN MATHEMATICIANS FROM ANCIENT TO THE MODERN AGE

In this section, we have listed the names of some of the female mathematicians. For more information, see [13].

- Ancient age and Medieval age Theano (546 BC): Theano, known as Theano of Croton, was born in 546 BC, probably in Crete, and it is believed that She was the wife of the Greek mathematician and philosopher Pythagoras. Inspired by Pythagoras, Theano had some significant contributions in Mathematics as well as physics. Her principal works included a Life of Pythagoras, a Cosmology, The Theorem of the Golden Mean, The Theory of Numbers, The Construction of the Universe, and work titled On Virtue.
- Hypatia (370-415 AD): Hypatia, the mathematician and philosopher of Theon, was born in Alexandria, Egypt, in 370 AD [4]. She is, in fact, the first well-recognized female mathematician. She lectured on mathematics and philosophy in the Platonist school at Alexandria, and remarkably in about 400 AD, she was appointed as the head of that institution. She collaborated with her father on commentaries of classical mathematical works Apollonius of Perga's Conics and Diophantus of Alexandria's Arithmetic, as well as an astronomical table which was possibly a revised version of Book III of her father's commentary on the Almagest [7], the Ptolemy's version of the solar system and its motion.
- Modern age The modern age has set up its journey with a big jump in science and technology. Western civilization got a kick after the slumbers of the medieval era. Johannes Gutenberg's printing press arrived in 1450 and changed everything. Universities in Bologna, Oxford, Salamanca, Paris, and elsewhere began to flourish. Leonardo da Vinci was in his prime, and Christopher Columbus was discovering a new world. Furthermore, the new era of Mathematics was about to blossom, holding the hands of Newton, Leibniz, Euler, Gauss. In this vast majority of men in the field of Mathematics, there have been few exceptional.
- Maria Gaetana Agnesi (1718-1799): The Italian mathematician Maria Agnesi is considered a brilliant mind with an exceptional contribution to mathematics. Her father was a wealthy professor of mathematics at the University of Bologna and encouraged his daughter's interest in scientific matters by securing a series of distinguished professors as her tutors. In 1748, She published one of the earliest textbooks on differential and integral calculus, *Istituizioni Analytiche*, which she originally wrote to instruct her younger brothers. The book was initially written in the vernacular and was considered one of the pioneer books of calculus throughout Italy. Two years after the book's publication, she has appointed a position in the mathematics department in Bologna on the Pope's recommendation, Benedict XIV, although she never took that. The paper, *On the Rotation of a Solid Body about a Fixed Point*, gained global recognition. As a result, she was awarded the prestigious prize *Prix Bordin* from the French Academy of Sciences. The judges considered the paper so exceptional that they raised the reward from 3,000 to 5,000 francs. At the end of that year, she was elected to membership in the Russian Academy of Sciences.
- Sophie Germain (1776-1831): Sophie Germain was born in Paris in the year 1776. After completing the study in her father's library, she entered the newly founded *École Polytechnique*. However, she faced a massive problem as females are not allowed in the university. Nevertheless, her life changes when she meets JosephLouis Lagrange, who gave her support and care for several years. Her work on vibrating plates won the prize awarded by the French Academy of Science.
- Emmy Noether (1882-1935): One of the greatest algebraists of all time, Emmy Noether was born in 1882 in Erlangen, Germany. Being a woman, she faced many obstacles as most of the universities did not simply allow women. However, surmounting all these



obstructions, she finally entered the University of Göttingen in the year 1915. Her work completely changed the shape of mathematics as well as physics. In 1918, Noether presented her famous theorem, which states that every differentiable symmetry of the action of a physical system has a corresponding conservation law. Furthermore, this theorem has a profound impact on physics. Theoretical physicist Frank Wilczek of MIT once commented "That theorem has been a guiding star to 20th and 21st-century physics". For her outstanding mathematical contribution, she got the invitations to address the International Congress of Mathematicians at Bologna in September 1928 and again at Zürich in September 1932. At that time, with the rise of Hitler, she was forced by Nazis to leave Germany for being Jewish. She flew to the USA and started giving lectures at the Institute for Advanced Study, Princeton.

Julia Robinson (1919-1985): Julia Robinson was born on December 8, in St. Louis, Missouri, USA. At the age of 9, she was diagnosed with scarlet fever, and the doctor predicted that she would not live more than 15. From an early age, she had an early passion for mathematics. After graduation, she settled down in UC Berkley and took Hilbert's famous 10th problem for her lifetime problem. She developed Robinson Hypothesis, which transforms Hilbert's 10th problem into a more straightforward form. Although the last puzzle was solved by the Soviet mathematician Yuri Matiyasevich, he gave full credit to her, and it can be cited in his statement "The name of Julia Robinson cannot be separated from Hilbert's 10th problem." Robinson was the first woman to serve as president of the American Mathematical Society. She was also the first woman mathematician to be elected to the U.S. National Academy of Sciences in 1975. She died on July 30, 1985, at the age of 65.

Maryam Mirzakhani (1977-2017): Mirzakhani was born in May 1977 in Tehran, Iran. She attended school there and twice won gold medals for Iran in the International Mathematical Olympiad. The choice of becoming a mathematician was not easy at all for a woman in Iran. She was one of the greatest geometers of her generation. Her primary interest was on the Riemannian surface, a rubber sheet-like object with many holes in it. In this topic, she developed techniques with several ramifications in seemingly distant fields like quantum field theory. After becoming the first women mathematician and the first Iranian to win the Fields Medal, she became the icon. One of her friends, K. Rafi, remembered [12] "Despite the fame and attention she received, Mirzakhani remained humble and grounded, always avoiding the spotlight.

V. WHY ARE THE NUMBERS SO FEW?

In the article "Mathematics is a genderless world," Karen Uhlenbeck vigorously attacks the following questions [11]: "Can women learn mathematics just as well as men? Of course! Then why haven't we heard of more women mathematicians (if we have heard of any)?" In this male-dominating society, there is very little room for a woman, and often they find discouragement and impediment from the community and their family. The mindset of the society can be easily anticipated from Uhlenbeck's quotation "In earlier times, male mathematicians have been heard to joke: I only knew two women mathematicians, the one wasn't a mathematician, and the other wasn't a woman. The latter is believed to be a reference to Emmy Noether, who certainly was a great mathematician but apparently didn't meet everyone's standard of feminine beauty." Kelley [9], in her article "Why were so few mathematicians female?", commented that Considering the little support that they have received and the many barriers that have been placed in their way, it is remarkable that so many women have accomplished so much in mathematics. In August 2018 at ICM in Rio de Janeiro, June Barrow-Green [2] presented the condition of women mathematicians from ancient times to the modern age in her lecture "The Gender Gap in Mathematical and Natural Sciences from a Historical Perspective." She provides some examples of the challenges and prejudices faced by women mathematicians during the last two hundred and fifty years. Topaz, a professor at Macalester College, and Macalester computer scientist Shilad Sen find in their analysis [8] that women hold 13,000 editorship positions on 435 math journals, just under 9 per cent of all math journals editorial positions. The median journal has an editorial board with 7.6 per cent of editorships held by women, but one in ten journals has no female editors. The creepy mindset of society has another face too. Sometimes it tries to lower the female accomplishment, and such an incident does not rate at all. Mathematician Sarah Brodsky says that after receiving the National Science Foundation's prestigious Graduate Research Fellowship, one of her colleagues told her that she had won the award only for being a woman [8]. Gender disparities are a widespread problem in all aspects of the education system, but it reaches its height in mathematics. This field has traditionally been thought of as a male-dominating field, and women are usually considered a novice.



VI. SOME INITIATIVES FOR THE IMPROVEMENT

In 1971, the Association for Women in Mathematics (AWM) establishment was a significant step in this regard [6]. The first president of AWM was Prof. Mary W. Gray. The AWM sponsors several awards and prizes such as: • Alice T. Schafer Prize • Louise Hay Award • M. Gweneth Humphreys Award • Ruth I. Michler Memorial Prize • AWM Service Award After the formation of AWM, several other organizations such as – The Joint Committee on Women in the Mathematical Sciences (1971), – European Women in Mathematics (1986) – The Women in Mathematics Committee of the European Mathematical Society (1991) – Femmes et Mathématiques (1987) – The Canadian Society Committee for Women in Mathematics (1992) – The London Mathematical Society Women in Mathematics Committee (1999) Have been established to support women in mathematics. Indian Women and Mathematics (IWM) is a collective of Indian mathematicians that has been in existence since 2009. Over the years, the main objective of this organization has been to encourage more women to pursue higher education in mathematics and organize events and networking opportunities that will enable them to take up careers in mathematics. In 2015, this organization acquired the National Board of Higher Mathematics (NBHM) support for promoting mathematics education and encouraging research in universities and institutions.

VII. CONCLUSION

For centuries women were disregarded as mathematicians, and the gender gap in mathematics remains very real. According to the annual survey of the mathematical sciences in the U.S., female PhD degree holders are only 30 per cent in 2015-2016. This percentage is comparatively deficient in modern days, where each female student is supposed to have an equal opportunity like a man, but the participation ratio tells a different story. Women still lack support from their families and society, and active women in mathematics are still a dream in our community.

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