FROM SHADOWS TO LIGHT: WOMEN AND THEIR CONTRIBUTION TO MATHEMATICS THROUGH TIME, FROM ANTIQUITY TO THE MOON

DAS SOMBRAS À LUZ: AS MULHERES E SUA CONTRIBUIÇÃO PARA A MATEMÁTICA AO LONGO DO TEMPO, DA ANTIGUIDADE À LUA

DE LAS SOMBRAS A LA LUZ: LA MUJER Y SU APORTE A LA MATEMÁTICA A TRAVÉS DEL TIEMPO, DESDE LA ANTIGÜEDAD HASTA LA LUNA

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ABSTRACT

From the earliest civilizations to the present day, women have played a fundamental role in the development of mathematics. Despite the numerous barriers and discrimination, they have faced, their legacy has been silenced and relegated to the background for centuries due to gender bias and a lack of recognition of their contributions. Among them are the woman who used the identity of a man to gain admission to an analysis class, and the African- American mathematician who collaborated on the Apollo 11 mission; each of them interested in mathematics and supporting the world

Keywords: Women. Mathematics. Middle Ages. Ancient Times. Discrimination.

RESUMO

Desde as primeiras civilizações até os dias atuais, as mulheres desempenharam um papel fundamental no desenvolvimento da matemática. Apesar das inúmeras barreiras e discriminações que enfrentaram, seu legado foi silenciado e relegado a segundo plano durante séculos devido ao preconceito de gênero e à falta de reconhecimento de suas contribuições. Entre elas estão a mulher que usou a identidade de homem para ser admitida em uma aula de análise e o matemático afro-americano que colaborou na missão Apollo 11; todos eles interessados em matemática e em apoiar o mundo.

Palavras-chave: Mulheres. Matemática. Idade Média. Tempos Antigos. Discriminação.

RESUMEN

Desde las primeras civilizaciones hasta la actualidad, la mujer ha desempeñado un papel fundamental en el desarrollo de la matemática. A pesar de las numerosas barreras y

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discriminaciones que ha enfrentado, su legado ha sido silenciado y relegado a un segundo plano durante siglos, debido a sesgos de género y la falta de reconocimiento de sus aportes. Entre ellas se tiene a la mujer que utilizó la identidad de un hombre para lograr ingresar a una clase de análisis, o bien la matemática afrodescendiente que colaboró en la misión Apolo 11; cada una de ellas interesadas en la matemática y dar su aporte al mundo.

Palabras claves: La mujer. Matemática. Edad Media. Edad Antigua. Discriminación.

INTRODUCTION

Over the years, mathematics has had a number of precursors who have managed to position it as one of the most important disciplines for the development of humanity, this is necessary for many of the other sciences, not to say for all. The different people who have made their contribution to mathematics have been out of the desire to learn from it and experience what they know with mathematics and thus great theories, theorems, propositions, lemmas and others have emerged, each one useful for a different branch within the study of science.

Among these precursors who made contributions to mathematics is one unfortunately excluded from the mathematical world but who has made great contributions over the years, we speak of women, who since the beginning of civilization and mathematical knowledge made a number of contributions in different areas, regardless of the fact that because she was a woman she should not interfere in the affairs of science, she did not have a voice or vote to give her opinion, not even when she could be right in what she presented, so much was the conflict that could lead her to death if she insisted.

Against all odds there are some very brave women determined to succeed in the mathematical world who over the years despite being seen as irrational beings achieved great contributions to mathematics, the decision is made to collect information on the contribution of women to mathematics, to give it the recognition it deserves since it was very difficult for her at the beginning to be part of mathematics. something so great and wonderful, it is also too cruel that they could not advance their dreams for the simple fact of having been born a woman, therefore, it was important to know and highlight those who in the beginning even gave their lives for this beautiful science.

WOMEN IN ANTIQUITY

From the very beginning of civilizations, women were considered "as a non-rational human being, sometimes they were called 'creatures', or as something imperfect" (Fernando, 2019, p. 1). From the beginning in ancient times women were seen as an inferior being and getting that to change is almost impossible during their time, but in spite of everything there were two well-known and key figures in the mathematical world such as Theano of Crotone and Hypatia of Alexandria.

THEANO OF CROTONE

When referring to Theano is talking about the first woman of whom there are historical indications of her contribution to mathematics, within her history it is known that she was part of the Pythagorean School of which she became a teacher, in the same way her father was part of the "religious group of the Orphics (which proposed an innovative interpretation of the human being, as composed of a body and a soul, an indestructible soul that survives and receives rewards or punishments beyond death)". (Barbarán Sánchez, 2017, p. 1)

Theano was a woman of arms, who defended her legacy until after the death of Pythagoras, this led her to make very valuable contributions to mathematics such as: The Golden Number, The Pythagorean Pentagonal Star, Golden Rectangle and "she left some writings of a moral nature, being considered one of the first philosophers in history. He writes "On Piety", in which he describes the responsibility of men and women in the maintenance of order, justice and harmony". (Fayanás, 2016, p. 2)
Among the works that historians attribute to Theano, his contributions on the golden ratio stand out, as stated (Ethel W. McLemore, 1979 cited in Barbarán Sánchez, 2017, p. 2):

> The main work attributed to Theano deals with the famous golden ratio. Like the geometric constant π, the golden number Φ (denoted after the Greek sculptor Phidias) is an irrational number that appears very frequently in nature and whose approximate value is 1.6180. In geometry, a golden rectangle is one whose sides are in the golden ratio, for example, 13:8. In both Ancient Greece and Egypt, this ratio was used to construct numerous buildings (the Parthenon, the pyramids, etc.). We currently know that some growth patterns observed in nature follow the golden ratio, such as the spirals of the Nautilus shell and the double spiral of sunflower flowers.

The knowledge of the Pythagorean School1 has survived to the present day thanks to Pythagorean School[4]: it was in its beginnings a sect, in which religion and religion were curiously mixed the work of dissemination of "Theano stood out for his wisdom and actively participated in writing several treatises, highlighting his formulation of the golden ratio. Theano is the oldest symbol that mathematics can also be feminine." (De Francisco Heredero, et al., 2011, p. 27)

[4]Pythagorean School: it was in its beginnings a sect, in which religion and religion were curiously mixed

HYPATIA OF ALEXANDRIA

Hypatia of Alexandria was the most brilliant woman of her time for her knowledge, beauty and determined struggle for her principles and ideals.

It is important to note that Hypatia had a Neoplatonic philosophy, which she defended and regardless of the fact of being a woman, she entered the philosophical world, and was known as "the philosopher". "The importance lies mainly in the fact that she was one of the first women in history who contributed to the development of mathematics, she managed to stand out among that group of wise men who competed in astronomy, philosophy, mathematics and other sciences." (Briceño V., 2022, p. 2)

Hypatia of Alexandria, as her name says, was born in Alexandria. Egypt between 355 and 370 does not have the exact year. "There is no information about Hypatia's mother, however, the father was a well-known astronomer and mathematician named Theon." (De Francisco Heredero, et al., 2011, p. 33).

In 415 A.D., when Hypatia was on her way home, she was attacked by a mob who stripped her naked and killed her atrociously with pieces of broken pottery and dragged her through the streets (National Geographic History, 2016, p. 1) explains the death as follows:

> In the month of March of the year 415, in the middle of Lent, a crime shook the city of Alexandria: a vociferous mob attacked the respected and wise Hypatia, killed her and raged against her remains. The murderers were part of "a multitude of believers in God," who "sought out the pagan woman who had entertained the people of the city and the prefect with her incantations." They dragged her to the interior of a church, and there they stripped her naked and dismembered her, tearing her flesh with shells and tiles, and after she died they burned her remains in a bonfire to erase her memory.

Hypatia's most important work was in Algebra, she wrote a commentary on the arithmetic of Diophantus, from 13 books. Diophantus lived and worked in Alexandria in the third century, (De León & Sardón, 2016, p. 1) explains the following:

> Hypatia's comments showed that arithmetic is more than calculus, this paper dealt with the solutions of algebraic equations and the theory of numbers; They also included some alternative solutions to the indeterminate (Diophantine) equations and numerous new problems, which were later included in the Diophantine manuscripts. Another contribution of his was to demonstrate the generality and indeterminacy of the problem of Diophantine equations by substitution of unknown numerical values that are not related and that are not multiples, powers, square roots or fractions of the originals.

In ancient times the discrimination experienced by women in their homes and cities is remarkable, but it is admirable to see how some fought against everything to begin that

small but significant push for women, it is totally evident that they lived hidden and without the opportunity to advance but this was not an impediment for Theano and Hypatia who forged the beginning of the light for women in anything other than being a housewife and allowing her participation in mathematics, although they made their best effort, this was not recognized in their time.

MIDDLE AGES AND MODERN AGE, WHAT DID WOMEN DO?

In the Middle Ages and Modern Ages there is a surprising way to go, from the time of the obscurantism of mathematics in which the reasons why during this age the advances in mathematics were so scarce and women are not reflected in it.

On the part of the Modern Age, it is possible to appreciate the change in mathematics and the great contributions thanks to the Renaissance, but the story becomes interesting when in order for a woman to talk about mathematics she had to disguise herself as a man and once discovered it was very difficult for her to position herself within mathematics, despite her great contributions.

MATHEMATICS IN THE MIDDLE AGES

The Middle Ages is the historical period that spans from the fall of the Western Roman Empire (476) to the Discovery of America (1492), it should be noted that other authors place it in "the year 476 with the disintegration of the Western Roman Empire and ends with the fall of the Byzantine Empire at the hands of the Ottoman Turks in the fifteenth century (1453)" (Suárez, 2022, p. 1).

During the Middle Ages mathematics was in a deep sleep, not because it was wanted that way, but it was the only way that it would last over time, but it did not last long the twelfth century was decisive for the destiny of Europe, for its culture, science and mathematics, the so-called Dark Ages.

This period of darkness is entitled the Dark Ages, which (Marín, 2022) defines it how: It was a medieval practice of the clergy and the upper echelons that consisted of blocking the spread of knowledge, reason and culture to the rest of the people. That is, to keep the population on the margins of all scientific knowledge inspired by reason and research. It was the church and theocentrism that were in charge of dictating what was right and what was not; what information and knowledge was allowed to the population and what was not. In short, obscurantism placed dogma above reason.

This is how mathematics was about to disappear in that great medieval darkness, but thanks to great people who still believed in its importance it managed to survive and become one of the most important disciplines.

MATHEMATICS IN THE MODERN AGE

The Modern Age is known as the third period into which the history of humanity is usually divided, and which includes between the middle of the fifteenth century and the end of the eighteenth, in other words, from the discovery of America (1492), to the French Revolution (1789).

The reappearance of mathematics was quite a spectacle, but unfortunately once again the woman was out of all this, but it would not be for long since at this time there was a very capable and determined woman to expose her knowledge and regardless of having to change her identity she succeeded.

SOPHIE GERMAIN

Mathematics, Physics and Self-Taught; although Sophie Germain was between two periods: Modern and Contemporary Age, it will be placed in the Modern Age, since her birth and first notions of mathematics were given in this period.

He was 13 years old when he learned what the end of the man whose death meant the end of the

Twilight of the Golden Age of Greek Mathematics. "She was so shocked by that story that she decided that she also wanted to be a mathematician, she was deeply surprised to see how mathematics could abstract someone" (Rodríguez, 2018).

She was a very enthusiastic young woman and dedicated to knowing more about what happened years ago and how this was still part of her present and future. Unfortunately, in her time women were not allowed to study, she always had to research alone, since the scientific community of her time was totally male.

This was not an impediment to studying; she was 18 years old in 1794, when "the Polytechnic School of Paris, l'Ecole Polytechnique, was founded, as women were not admitted, she managed to get notes from some courses" some friends passed her the notes of the lectures, in particular those of Lagrange[5], who taught analysis" (Liedo, 2022, p. 3).

[5] Lagrange: Italian physicist, mathematician and astronomer. He made transcendental advances in multiple branches of mathematics, developed Lagrangian mechanics and was the author of innovative works on astronomy.

She lived in an era of prejudice and chauvinism[6], and in order to conduct her research she was forced to assume a false identity, study in terrible conditions, and work in intellectual isolation. "She enrolled in the Ecole Polytechnique de Paris with the name of a former student of her and some highly relevant professors noticed this student and although they soon discovered her true sex, they protected her" (Moreno, Ramírez, De la Oliva, & Moreno, 2022).

The name of this former student was Antoine-Auguste Le Blanc, he had to steal the identity of this former male student to continue his studies, so it was that he signed many of his works under the name of M, Leblanc to hide his true identity this allowed him to make his contributions and obtain knowledge of great mathematicians, one of these being Lagrange who when teaching the course of analysis requests a final project, "Sophie presented a memoir under the name of M. Leblanc; Lagrange was impressed by the originality of the work and wanted to meet the author to congratulate him personally" (Biographies, 2022).

FERMAT'S THEOREM

Fermat's last theorem, which states that "it is impossible to decompose a cube into two cubes, a bisquare into two bisquares, and in general, any power, apart from the square, into two powers of the same exponent" (De Francisco Heredero et al., 2011, p. 61). Sophie researched deeply on this theorem finding the solution for certain prime exponents (Rodríguez, 2018) emphasizes:

Germain managed to prove for a particular type of equations that when 'n' is a prime number as two times that prime number plus 1 is also prime. For example, if I take the prime (number) 5 and multiply it by 2 and add 1 to it is 11, that's also a prime number. Those prime numbers are called the Sophie Germain primes: when you double a prime and add 1 the result is also a prime number", This is how the Sophie Germain primes were born: a prime number p is a Sophie Germain prime number if 2p + 1 is also a prime number. By proving one of the cases of Fermat's enigmatic equation, Germain paved the way for other scientists to try to elucidate it. Centuries later and after several years of dedicating himself to it, Wiles would solve all the cases of the theorem. One of the most difficult equations to understand in history, Germain's contribution was very significant, even more so if one considers the limitations that women of her time had.

[6] Chauvinism: it is an exacerbated feeling or attitude, through which one's own nation is exalted above the rest.

That is why in both Ages the contribution of Women was so scarce. First it is important to highlight the great conflict that took place between Christianity and the development of the sciences, the few documentations that are preserved refer to the deterioration of mathematics at this time, but it is important to point out that in the East contributions were made by them, the Middle Ages were generally one of the worst for mathematical development.

On the other hand, the Modern Age and the Renaissance with respect to women and the previous ages was not a great change, they were not allowed to study, give their opinion and anything that was related to science and much less to mathematics. Therefore, they continued to be seen as an irrational creature until that moment the contributions made in antiquity did not have no validity and those made by Sophie Germain, much less to such an extent that they only stole her works and then claimed to be hers, which is why it can be said that the work of women was not scarce since proving one of Fermat's Theorems is not an easy job, the detail is the time where it was done and the little consideration for women.

CONTEMPORARY AGE, THE ENHANCEMENT OF WOMEN IN MATHEMATICS

The contemporary age where there are very bright and determined women who did not escape being humiliated and excluded for being a woman, but the important thing about this time is that women demonstrated what this fact really did and imposed their knowledge above many achieving great advances for humanity, without those contributions man would never have known computer science or better yet reached the moon, Someone should never be underestimated because of their gender or skin color and here it was proven that everyone has the right to an opportunity.

FIRST FEMALE PROGRAMMER

Ada Lovelace, nicknamed by her great friend Charles Babbage as "the number charmer", was the first person to publish a computer program and is considered one of the first programmers in history.

Ada distinguished what was the difference engine (a contraption with the ability to solve second-degree polynomials) from the analytical engine (capable of performing repetitive operations of mathematical calculation, by incorporating elementary processes and programming elements). He analyzed and described the mechanism of the analytical engine, a true calculator, which is the antecedent of modern computers, since it had an input sequence, processing unit, memorization and output of data and was programmed with punched cards.

ALGORITHM FOR CALCULATING BERNOULLI NUMBERS

By managing to make this distinction in his notes he managed to establish an algorithm to calculate Bernoulli's numbers4, this algorithm is best known for being the first program in the history of computer science. Bernoulli numbers constitute a sequence of rational numbers with deep connections in number theory.

He developed a program for the Analytical Ingenuity that calculated Jacob Bernoulli's numbers, and analyzed the orders given to him, as well as their correct application. (De León and Sardón, Mathematics and its Borders, 2016) points out:

The notes were denoted alphabetically, from A to G, with G being a description of Bernoulli's calculation algorithm. Bernoulli numbers are a succession of rational numbers that appear in Taylor expansions of functions such as tangent and hyperbolic tangent. They even appear in the Riemann Z-function. Historically, these numbers arise from trying to find a solution to the sum of the powers of the natural numbers. However, none of its codes were tested because the machine was never built. He left his articles signed with the initials A.A.L (Auguste Ada Lovelace).

Only a part of her work is preserved, some notes and notebooks, because many of her writings were destroyed by her mother, she did not agree that her daughter should dedicate herself to mathematics, she was even called Babbage's assistant for the simple fact of being a woman.

Katherine Johnson

An African-American girl who told everything; the steps he needed to cross the street, the steps to the church, the number of dishes he cleaned, the stars he saw, everything that could be counted. An African-American girl who grew up in a time when racial segregation was a reality and who, even though she had, a priori, few opportunities, became an excellent mathematician.

For Johnson, life was very complicated because of two things, the first because she was a woman and the second because she was of African descent, these two things played against her, but neither was an impediment for her to fight for a better future. In 1937 the only option for an African-American woman to work outside the home was to dedicate herself to teaching

NASA Math

It was 1950 when she learned that NACA5, NASA's predecessor organization, is looking for African-American women to perform calculations. Something that had become common.

NACA: NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

In government agencies during World War II. Although he did not make it to the first call, Johnson began working at NACA in 1953 (Montoya, 2020, p. 4) argues that:

> As an expert in geometry, mathematics and physics, Johnson was dedicated to performing all the operations, calculations and checks required by the agency's aeronautical engineers. Although his work was limited to performing calculations, over time Johnson would begin to gain space in the agency. She attended the engineers' meetings and was in charge of verifying the calculations made by the computers, recently introduced into the agency. The barriers she initially faced as an African-American woman and person gave way over the years thanks to her incalculable talent.

"You tell me when and where you want [the spacecraft] to land, and I'll tell you where, when, and how to launch it," scientist Katherine Johnson (Newport News, West Virginia, 1918) once said.

Mercury Mission

She was in charge of the calculations of Project Mercury, developed by NASA6 between 1961 and 1963 and who calculated the trajectory of the first space trip made by Alan Shepard aboard the Mercury Redstone 3 in 1961.

"One of the most prominent stories about Johnson occurred in 1962, when astronaut John Glenn, the first American to orbit the Earth, insisted that Johnson revise the calculations of his trip around the planet" (BBC News World, 2020).

APOLLO 11 AND APOLLO 13 MISSION

Katherine calculated the trajectories of Apollo 11, which took man to the Moon in 1969, (García Ferrero & Moreno, 2018) states:

Johnson was in charge of calculating the moment when the Eagle lunar module, from which the astronauts would descend, should leave the satellite so that its trajectory would coincide with the orbit described by Columbia and could thus dock with it to return to Earth. "I had done the math and I knew they were right, but it was like driving this morning, anything could happen."

Another important event in history was Apollo 13, it is worth mentioning that it was his calculations that helped land the failed mission.

Johnson transitioned to the computer age and worked on the shuttle program while writing or co-writing 26 research reports before retiring in 1986, NASA said.

"She said she was very proud of her contributions to the first lunar mission, which included the calculations that synchronized the lunar landing craft and the command module in orbit" (La Vanguardia, 2020).

NASA THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

How did women manage to go from obscurity to become a fundamental part of the history of mathematics?

To answer this question, we only have to observe the dedication, perseverance and interest on the part of each of the women described here, who regardless of being despised, distanced, excluded gave up, we cannot know if as time went by they read stories of their ancestors and realized that they were going through the same thing as them, That perseverance was what made women achieve more than positioning themselves within the mathematical world, they managed to be respected and known not as an irrational being but as a superior one, since making man orbit the Earth and step on the Moon for the first time is unparalleled.

It is incredible to see how women were excluded from much of history and even steal their contributions, but when it was really needed there it was and it was happy to wait since women deserve equal respect as men. Therefore, the lesson that these brilliant mathematicians and women leave us is to never faint and always move forward no matter how many times they tell us no.

The significant progress that women had in the field of mathematics, a worthy example to follow, never let themselves be underestimated and although she was not taken into account, she continued to place that name, woman of shadows as she was in ancient times in a fundamental part of the history of humanity and demonstrate that anyone can achieve.

FINAL THOUGHTS

From the very beginning of civilizations, women were considered as non-rational human beings, sometimes they were called "creatures", or as something imperfect, they could not do any work other than that of a housewife and if she wanted to do something outside of her routine she could be sentenced to death.

Theano of Crotona considered by some historians to be the first woman mathematician for whom today we have the joy of knowing the great Pythagoras and his different contributions. Hypatia of Alexandria, a woman dedicated to science, including mathematics and defender of her philosophy which led her to a tragic death, made very important contributions to recognized works of the time such as those of Diophantus, Apollonius and others.

The Middle Ages were one of the most difficult periods through which mathematics passed in the so-called obscurantism, in which many years of mathematical work and knowledge were lost, within which men and women had no opportunity.
In the Modern Age, on the other hand, there was the Renaissance, as its name indicates, everything was reborn except for women's rights, it is here that Sophie Germain comes into play, who, due to her desire to learn mathematics, had to change her identity to that of a man and thus be accepted as a recognized scientist.

The Contemporary Age, an age that favored women not from the beginning, but over the years in this is Ada Lovalace Byron, the first woman programmer and the first in the world, on the other hand, Katherine Johnson, an African-American who received double humiliation for being a woman and for being of color, but this did not stop her from being part of one of the most prestigious institutions in the world, the NASA and being a fundamental part of something historic such as stepping on the moon for the first time or making the journey to Earth orbit.

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