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THE HISTORICAL EVOLUTION OF MATHEMATICS BETWEEN THE XVI AND XVIII CENTURIES

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Abstract

To have a clear vision of the evolution and profound renewal that mathematical thought underwent in the XIX century, the "century of the golden age", we must first study the centuries that prepared the fertile ground for the great revolution of the XIX century. In fact, the great development that mathematics had in the XIX century was the result of a revolutionary journey that began in the XVI century and continued in the XVII and XVIII centuries. In this work we will highlight the contributions made by the XVI century, the XVII and XVIII centuries to XIX century mathematics, trying to focus on the most important mathematical achievements of these centuries, and in particular, the birth of "modern mathematics" in the XVI century, and, in the XVII centuries and XVII centuries, the construction of geometry in modern terms and the rise of mathematical analysis, as well as the first developments of these branches of mathematics.

Keywords: Mathematics, history of mathematics, innovation of mathematics

1. The development of mathematics in the XVI century

The XVI century is known to the general public above all as an era of extraordinary literary and artistic flowering, which began in Italy and then spread throughout Europe, where it reached its peak in the following century. This vision lacks one of the fundamental elements that make up the greatness of the XVI century, and that constitute the watershed from which the modern age begins. It is a question of the fact that the XVI century brought to the history of humanity the enormous contribution of the creation of modern mathematics, and the changes that took place so profound that they revolutionized the scientific world of the time. Mathematics develops in the abacus schools[1]: in these schools, the student is sought to be able to solve specific practical problems individually through the simple application of codified procedures and rigid formulas, of which neither justifications nor demonstrations are given: that the result solves the problem is the only thing that really interests the practical and is at the same time the only proof of validity for the rules applied. In essence, calculating proceedings are taught, even if presented in application to specific situations, can be generalized for the solution of all similar cases to which mechanically apply, however, guaranteeing the security of the result. The characteristics of the teaching given by the Masters of Abaco therefore create a mental attitude, against mathematics, profoundly innovative compared to tradition, allowing the development and affirmation of a new discipline: algebra. But it is precisely this interest aimed at the result, for the practical profit that can come, that stimulates attention and leads to overcome justify differences first towards

[1] The abacus schools were places used for the study of mathematics. The teachers, in fact, in these places had the task of teaching mathematics to young people. Another task of the abacus schools managers was to take care of the accounts of time workshops. The abacus came to carry out the calculations in the abacus schools. It was an instrument used since ancient times to perform simple arithmetic calculations, and consists essentially in a tablet containing grooves or parallel wires on which balls can flow.

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algebra and then towards the first attempts of the infinitesimal calculation: both disciplines, In fact, in the beginning do not have in their favour than the novelties of the results, deficient as they are of all the usual characteristics of the mathematical discourse. In the XVI century, therefore the algebra fully assumed its position between the mathematical disciplines and the pathway from the algebra to reach the current form can be divided into three phases: rhetoric, in which the equations are expressed in a discursive way with numbers and words; in which for clarity and speed of calculating the discursive ways are abbreviated; Symbolic, in which signs, symbols and numbers are used. All the work done around the algebra in Renaissance era receives a better formal accommodation from the lawyer and French political man François Viète[2]; He introduces the use of letters to denote the positive quantities known and unknowns, employing consonants and vocals respectively, and establishes the literal calculation rules applied to the solution of the second and third-degree equations: in essence, it processes the first second formulas The current concept.

2. The development of mathematics in the XVII century

In the XVII century, the "century of geniuses", analytic geometry and infinitesimal calculus were invented; it can certainly be said that the first years of the XVII century represented a decisive turning point for geometry, thanks to which the Euclidean horizon was enlarged. This evolution, however, took place with a certain continuity with respect to what was the geometric corpus constituted by the greek classics. The classics were interpreted in a critical-constructive light that gave the possibility to bring something new, to broaden knowledge, deepening, modifying and clarifying certain procedures and techniques; thus, projective geometry was born. The merit of having initiated these new studies goes in the first place to Girard Desaurges[3], whose theory of involution should be particularly remembered. He introduces, with very original nomenclatures, the notion of involution of six points on a straight line and treats with greater generality the conics which, like Apollonius, conceives as sections of a plane of a cone. A notable contribution to the themes of projective geometry also came from Blaise Pascal[4] who, in the short but

[2] François Viiète, Lord of Bigotière (1540 -1603), was a French mathematician and politician. As mathematician he is known above all for the introduction of synthetic algebraic notations capable of making the most compact and most stringent deductive developments; He can consider one of the eminent figures of the Renaissance period. He is also known with his Latinized name, Franciscus prohibits. The activities of him are divided between an intense political life and a series of mathematical research. Viiète dedicates to mathematics only the time that remains free from political commitments, but nevertheless he manages to give considerable contributions to Arithmetic, algebra, trigonometry and geometry.

[3] Girard Desargues (1591 -1661) was a French mathematician, considered one of the founders of projective geometry. Desargues studies and writes about practical topics such as perspective and stone cutting (stereotomy) for use in buildings and sundials. Although he was familiar with the texts of the mathematicians of his time and of the Greek geometers (in particular of Apollonius and Pappus), he used a colloquial language, devoid of formulas and technicalities. This gives him criticism and little consideration on the part of his contemporaries; however, he expresses his appreciation for Pierre de Fermat. Indeed, he has general objectives, writes with substantial rigor and realizes the innovative scope of his results. His most important work is entitled Brouillon project d'une atteinte aux evenemens des rencontres du Cone avec un Plan, which can be translated as a draft of an essay on what is obtained by dissecting a cone with a plane. Only a few copies of this essay were printed in 1639 of which only a handwritten copy by Philippe de La Hire survives and rediscovered by Michel Chasles. It is a small book, but it constitutes an introduction to a theory of conics unified through the invariant properties by projection. The famous Desargues theorem which states that two triangles in perspective have the intersections of the corresponding collinear sides is published in 1648 by Bosse in a text on perspective.

[4] Blaise Pascal (1623 - 1662) was a mathematician, physicist, philosopher and theologian French. Child prodigy, he was taught by his father. Pascal's early works are related to natural sciences and applied sciences, contributing significantly to the construction of mechanical calculators and the study of fluids: he clarified the concepts of pressure and empty expanding Torricelli's work; he also wrote important texts on the scientific method. At the age of sixteen he wrote a treatise on projective geometry and from 1654 he worked with Pierre de Fermat on the

noteworthy Eassy pour les contiques (1639-1640) presented what we now call "Pascal's Theorem" or "the hexagram": in a hexagon inscribed in a conic, the opposite sides (two sides of the hexagon are said to be opposite if there are two other consecutive sides between one and the other) meet at three points of the same straight line. After Desargues and Pascal, projective geometry, at least for what concerns the XVI and XVII centuries, did not present particularly noteworthy developments, even if there were some valid studies in this direction: the XIX century will see the revival of this discipline. In the XVI century algebra also developed widely, for example, through the work of Newton[5], Newton, the discovery (1665) of the famous formula of the binomial that we find, among other things, in the Wallis Algebra of 1685. The developments in algebra caused new approaches to geometric problems. Pierre Fermat[6] in his Ad locos planos et solidos isoagoge (written before 1637) introduces, in a way very close to ours, the coordinates that, among other things, it was Gottfried Wilhelm von Leibniz[7] who called in this way. René Descartes[8] in his Géometrie, of 1637, gave the first significant algebraic representation of geometric entities. And it is precisely the study of geometric places as a

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theory of probability which strongly influenced modern economic theories and social sciences. After a mystical experience following an accident in which he had risked his life, in 1654, he abandoned mathematics and physics to devote himself to religious and philosophical reflections.

[5] Isaac Newton (1642 -1726) was a mathematician, physicist, natural philosopher, astronomer, theologian, historian and alchemist English, considered one of the greatest scientists of all time, also holding the role of director of the English mint and that of President of the Royal Society. Known above all for his contribution to classical mechanics, he contributed in a fundamental way to more than one branch of knowledge, occupying a position of great importance in the history of science and culture in general, with his name being associated with a large amount of laws and theories still taught today: we thus speak of Newtonian dynamics, of Newtonian laws of motion, of the law of universal gravitation; more generally, Newton ianism is referred to as a conception of the world that influenced European culture throughout the XVII century. Attracted by natural philosophy, he soon began to read the works of Descartes, in particular The geometry of 1637, in which curves are represented by means of equations; in the years in which he was a student at Cambridge two important figures presided over the chair, Isaac Barrow and Henry More, who exerted a strong influence on the boy; in the following years, he built his mathematical and experimental discoveries by referring to a small group of texts: he published the Philosophiae Naturalis Principia Mathematica in 1687, a work in which he described the universal law of gravitation and, through its laws of motion, built the fundamental rules for classical mechanics, sharing with Gottfried Wilhelm Leibniz the paternity of the development of differential or infinitesimal calculus. He contributed to the scientific revolution and the progress of heliocentric theory: he was responsible for the mathematical systematization of Kepler's laws on the movement of the planets; in addition to deducing them mathematically from the solution of the problem of dynamics applied to the force of gravity (two-body problem) or from Newton's equations of the same name, he generalized these laws by sensing that the orbits (such as those of comets) could be not only elliptical, but also hyperbolic and parabolic, also demonstrating that the same laws of nature govern the movement of the Earth and other celestial bodies. He was the first to demonstrate that white light is composed of the sum (in frequency) of all other colours, advancing the hypothesis that light was composed of particles, thus giving life to the corpuscular theory of light , as opposed to the wave theory of light sponsored by the Dutch astronomer Christiaan Huygens and the English Thomas Young and corroborated at the end of the XIX century by the works of Maxwell and Hertz; Newton's thesis instead found confirmation, about two centuries later, with the introduction of the quantum of action by Max Planck(1900) and with the article by Albert Einstein (1905) on the interpretation of the photoelectric effect starting from the quantum of electromagnetic radiation, later called photon; these two interpretations will coexist in quantum mechanics, as predicted by the wave-particle dualism.

[6] Pierre de Fermat (1601 - 1665) was a French mathematician and magistrate. He was among the leading mathematicians of the first half of the XVII century and made important contributions to the development of modern mathematics: with his method for identifying the maxima and minima of functions preceded the developments of differential calculus; he did research of great importance on the future theory of numbers, begun during the preparation of an edition of the *Arithmetical* of Diophantus of Alexandria, on which he wrote notes and observations containing numerous theorems. Precisely in one of these "marginal" observations he enunciated Fermat's last theorem (which he believed, most probably wrongly, to have proved), which remained unproven for more than 300 years, until the work of Andrew Wiles in 1994; independently of Descartes he discovered the fundamental principles of analytic geometry and, through correspondence with Blaise Pascal, was one of the founders of the probability.

[7] Gottfried Wilhelm von Leibniz (1646-1716) was a philosopher , mathematician , scientist , logician , theologian , linguist , glottoteta , diplomat, jurist , historian , German magistrate . Considered the precursor of computer science, neuroinformatics and automatic computing, he was the inventor of a mechanical calculator called the *Leibniz machine*; moreover, some areas of his philosophy opened numerous glimpses on the dimension of the unconscious that only in the twentieth century, with Sigmund Freud, will we try to explore.

[8] René Descartes (1596-1650), was a philosopher and mathematician French, one of the main founders of mathematics and philosophy of modern. Descartes extended the rationalistic conception of a knowledge inspired by the precision and certainty of the mathematical sciences to every aspect of knowledge, giving life to what is now known as continental rationalism, a dominant philosophical position in Europe between the 17th and 18th centuries.

function of their algebraic representation that characterizes the birth of analytic geometry. In the works of the most talented mathematicians of the XVII century we find the use of the method of Archimede[9] and among the most important mathematicians of the XVII century who used this method to prove their discoveries we remember: Luca Valerio[10] who had dealt with the determination of the volume of the sphere In fact, he considers two solids: the bowl and the cone and conceives them as solids formed "by the superimposition of many very thin sheets of area equal to two by two". From this he deduces, in a very original way, that the volume of the bowl is equal to that of the cone. So knowing that the volume of the cone is equal to

$$V = \frac{\pi r^2 h}{3}$$

With h the height of the cone, we can easily trace the volume of the sphere. However, it was Bonaventura Cavalieri[11] who gave a more systematic form to the ideas underlying that principle that allowed Luca Valerio to establish the equivalence between the volumes of two solids (in the case examined between the bowl and the cone). Technically not rigorous today, Cavalieri introduces his method of indivisibles, considering flat and solid figures as constituted respectively by many very thin strips and by many very thin sheets to be considered indivisible.

Subsequently Evangelista Torricelli[12], referring to Cavalieri, will greatly expand these results. In the works of these mathematicians there are also the prodromes of the infinitesimal calculus and in particular, of the notion of integral. In fact, in 1679, Fermat published one of his memoirs in which for the first time the notion that today goes under the name of derivative appears. Fermat, after having addressed issues inherent to maximums and minimums, adopting derivation procedures, takes into consideration the problem of determining the tangent at a point to a curved line. But we can affirm that only with Isaac Newton and Leibniz there was the first theoretical arrangement of the infinitesimal calculus. Other very talented mathematicians contributed to the

[9] Archimedes' method constitutes a kind of long scientific letter sent by Archimedes to Eratosthenes, he reveals the heuristic procedure that led him to discover those values which he then rigorously demonstrated with the method of exhaustion. This procedure has a mechanical character, in the sense that it uses the principle of the lever, according to an intuitive way of doing that we can so briefly explain. Let us imagine that we have two solids A and B resting on a plane, the first of which is of a known volume V. Now imagine that we cut the tw o solids into very thin slices through planes parallel to the base and that, to balance each of the slices of A hanging on the end of a lever, it is necessary to hang the corresponding slice of B on the opposite side of the fulcrum at double distance. It is clear that, being able to repeat the speech until the slices are exhausted, in the end all A will be balanced by all B, hanging in the respective points of the lever, with which B will have a volume equal to half that of A, that is ½ V.

[10] Luca Valerio (1553 -1618) was an Italian mathematician. For his own mathematical skill was defined by Galileo "The new Archimede".

[11] Francesco Francesco Bonaventura Cavalieri (1598 -1647) was a mathematician and academic Italian . Cavalieri's fame is mainly due to the indivisibles method, used to determine areas and volumes: this method represented a fundamental step for the future elaboration of the infinitesimal calculus. It was above all Galilei himself who pushed Cavalieri to deal with the problems of infinitesimal calculus. Subsequently, it constituted a point of reference for some of the geometric research of the young Evangelista Torricelli.

[12] Evangelista Torricelli (1608 - 1647) was a mathematician, physicist and academic Italian. In the years from 1632 to 1641 he worked and studied in Rome with Father Castelli and then became secretary of Giovanni Ciampoli, a high prelate and intellectual devoted to Galileo, whom Torricelli followed in his government posts in the Marche and Umbria. In 1641 Castelli presented to Galileo, in his retreat in Arcetri, the manuscript of Torricelli's work entitled: *De motu graveum*, suggesting that he use him as a disciple and assistant. So it was and on 10 October 1641 Torricelli became Galileo's assistant, together with Vincenzo Viviani, and at Galilei's request and insistence he moved into his home.

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"birth" of the infinitesimal calculus, among them John Wallis[13] , certainly the most significant English mathematician before Newton, to whose name, in the history of mathematical analysis, researches relating to the calculation of whole wheat in which he anticipated the notions (gamma function) studied by Euler[14]. These mathematicians gravitated to one of the most prestigious institutions, the Royal Society, which was founded in 1660 and recognized with royal privilege in 1662. This scientific association moved the epicenter of mathematical studies from France to England in the second half of the XVII century. The Royal Society sponsored the publication (1712), under the title Commercim epistolicum, of documents and letters collected by a special committee in order to shed light on the dispute between Leibniz and Newton over the priority of the discovery of the infinitesimal calculus.

3. The development of mathematics in the XVIII century

The XVIII century saw the succession of many discoveries, which also landed in the field of mathematical analysis. Among the direct followers of Leibniz we remember: Jakob Bernoulli Bernoulli[15] , who was mainly interested in infinitesimal calculus; however, he deserves the credit for having treated the calculation of probability in a very systematic way, in a volume, Ars conjectandi, posthumously postulated in 1713. Another great mathematician was Euler, whose mathematical work was particularly extensive. Euler should be remembered as well as a great analyst (he made advanced studies on series and on the theory of logarithms; demonstrating that the logarithms of negative numbers are not real numbers, but imaginary numbers), also as a precursor of that branch of mathematics we now call topology. In the XVIII century, there were many other achievements of mathematical thought. Algebra, which in the XVI century had had a period of real splendor, allowing then, among other things, as we have seen, the birth in the XVII century of analytic geometry, in the XVIII century had developments that we could summarize in two directions: that which concerns the assumption of linear algebra, and that relating to the emergence of new criteria to tackle the study of algebraic equations. Maclaurin[16] and Gabriel Cramer Gabriel Cramer[17] are responsible for the first results relating to the first of the aforementioned directions. Giuseppe Luigi Lagrange[18] (1736-1813) also dealt with issues

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[13] John Wallis (1616 - 1703) was an English presbyter and mathematician. Wallis contributed to the development of infinitesimal calculus. Between 1643 and 1689 he was chief cryptographer of the Parliament of the United Kingdom and later of the royal court. He is also credited with introducing the symbol ∞ which denotes the mathematical concept of infinity.

[14] Leonhard Euler, (1707 - 1783), was a Swiss mathematician and physicist. He is considered the most important mathematician of the XVIII century, and one of the greatest in history. It is known to be among the most prolific of all time and has provided historically crucial contributions in several areas: calculus, special functions, rational mechanics, celestial mechanics, number theory, graph theory. Pierre Simon Laplace seems to have said "Read Euler; he is the teacher of us all".

[15] Jakob Bernoulli, (1654 - 1705), was a Swiss mathematician and scientist. He corresponded with Gottfried Leibniz from whose first writings on the subject he learned the *differential calculus* that he developed in the following decades, with the collaboration of his brother, Johann, and always under the supervision of Leibniz himself. His first writings on transcendental curves (1696) and on isoperimetry (1700 1701) are the first examples of such applications. His main work is *Ars Conjectandi*, published posthumously in 1713, a fundamental work for the theory of probability. The concepts of *Bernoulli sampling*, *Bernoulli's theorem*, *random variable Bernoulli* and *Bernoulli numbers* are related to his work and named in his honor. Furthermore, the first central limit theorem, or the law of large numbers, was formulated by Jakob himself.

[16] Newton's mathematician; he taught first in Aberdeen and then in Edinburgh. His scientific activity is directly linked to that of Newton.

[17] He was professor of mathematics, then of philosophy in Geneva known for his Introduction à l'analyse des courbes algébrique in which he deals in detail with the theory of algebraic curves

[18] Joseph-Louis Lagrange, (Torino, 25 gennaio 1736 – Parigi, 10 aprile 1813), he was an Italian mathematician and astronomer active, in his scientific maturity, for twenty-one years in Berlin and for twenty-six in Paris. He is unanimously considered one of the greatest and most influential European mathematicians of the eighteenth century. His most important work is the Mécanique analytique, published in 1788, with which rational mechanics was conventionally born. In mathematics, he is remembered for his contributions to number theory, for being one of the

involving notions relating to determinants (calculation of the area of a triangle and the volume of a tetrahedron). However, this great Turin mathematician concentrated his studies in particular on the themes concerning the second direction of development of XVIII century algebra, which has been mentioned above. In his memoir Reflexiones sur la résolution algébrique des équations (1771) he proposes "to examine the different methods of solving algebraic equations of various degrees looking for the general principles, and to show a priori why such methods succeed for the third and fourth degree and fail for the higher grades ". In fact, Lagrange's studies were going to overturn, so to speak, the classical procedure that had historically established itself (ie from the knowledge of the roots to that of their sum and their product). Another great mathematician of the same period, Pierre Simon Laplace[19] had the merit, always in this cultural context, analysis both in philosophical and technical terms, the foundations of the calculus of probabilities. He produced two notable works in this direction: Théorie analytique des probabilités (1812) and 1'Essai philosophique des probabilités (1814). Even geometry in the XVIII century, acquired new and interesting contributions; Gaspare Monge[20] founded what is called descriptive geometry. Although descriptive geometry derives, in a certain sense, from the projective one, it nevertheless has a different approach to principle.

Apart from the technical differences, in fact, the first provides suitable methods, based on the given representation, to reconstruct the studied body, while the second has as an almost unique purpose the representation of the object studied regardless of the possibility of following the reverse path reconstruction. Despite this, the concrete origins of these two branches of geometry are similar and can be found in the architectural designs and in the perspective studies of the great Renaissance artists and architects. Lazare Carnot[21] in turn had a notable role in the study of the generalization of geometric concepts that he presented in the work Géométrie deposition (1803). Throughout the second half of the XVIII century the results achieved in the infinitesimal calculus aroused considerable enthusiasm, but a certain confusion about its fundamental

founders of the calculus of variations, deducing it in the "Mecánique", for having outlined the foundations of rational mechanics, in the formulation known as Lagrangian mechanics, for the results in field of differential equations and for having been one of the pioneers of group theory. In the field of celestial mechanics he conducted research on the phenomenon of lunar libration and, later, on the movements of the satellites of the planet Jupiter; he investigated the problem of the three bodies and their dynamic equilibrium with the rigor of mathematical calculation. His pupils were Jean-Baptiste Joseph Fourier, Giovanni Plana and Siméon-Denis Poisson.

[19] Pierre-Simon Laplace, Marquis de Laplace (1749 - 1827), was a mathematician, physicist, astronomer and noble French. He was one of the leading scientists of the Napoleonic period, appointed Minister of the Interior in 1799 by Napoleon, who in 1806 conferred on him the title of Count of the Empire, then also appointed Marquis in 1817, after the restoration of the Bourbons. He made fundamental contributions in various fields of mathematics, astronomy and probability theory and was one of the most influential scientists of his time, also for his contribution to the affirmation of determinism. He put the final twist on mathematical astronomy, summarizing and extending the work of his predecessors in his five-volume work *Mécanique Céleste* (Celestial Mechanics) (1799 - 1825). This masterpiece transformed the geometric study of mechanics developed by Newton into one based on mathematical analysis.

[20] Gaspard Monge (1746 - 1818) was a French mathematician and draftsman, inventor of descriptive geometry. Most of his studies are contained in the publications Application of Algebra to Geometry (1805) and Application of Analysis to Geometry whose fourth edition, published in 1819, was modified by Monge shortly before his death. It contains among other results its solution of a partial differential equation of the second order. Gaspare Monge was also the first developer of orthogonal projection.

[21] Lazare Nicolas Marguerite Carnot (1753-1823) was a general, mathematician, physicist and politician French. In 1797 Carnot published the book “Réflexions sur la métaphysique du calcul infinitésimal”, in which he proposed a new foundation of Calculus (also showing all his interest in the applicative aspects). In 1801 he wrote the volume “De la corrélation des figures de géométrie” in which he expounds Carnot's theorem on triangles and states that many of Euclid's results are particular cases of this theorem. In 1803 he published his last mathematical work “Géométrie de position”. Between 1814 and 1815 he held the posts of governor of Antwerp and Minister of the Interior. Forced into exile, he retired to Magdeburg. In this period he devoted himself to studies on the steam engine with research that also influenced the studies of his son Sadi, who three years later formulated the second law of Thermodynamics.

principles continued to dominate. None of the methods then commonly used, neither the Newtonian one of fluxions, nor that of Leibniz based on the concept of differential, nor even that of d'Alembert who used the concept of limit, seemed satisfactory. Therefore Carnot, by examining the various conflicting interpretations, tried to show what the "true spirit" of the new analysis consisted of. In identifying the unifying principle, however, he made a wrong choice. In fact, he drew the conclusion that "the true metaphysical principles" of the infinitesimal calculus were "the principles of error compensation". His reasoning was more or less this: infinitesimals are “quantitées inappréciables” which, like imaginary numbers, are introduced only for the purpose of facilitating calculations and are eliminated when the final result is reached. "Imperfect equations" are made "perfectly exact", in the infinitesimal calculus, by eliminating those quantities, such as infinitesimals of higher order, whose presence can give rise to errors. To the objection that quantities that tend to zero are either zero or they are not, Carnot replied that "what we call infinitely small quantities are not simply any null quantities, but are instead null quantities determined by a law of continuity that regulates their relationship"; this reasoning is very reminiscent of Leibniz. The different methods adopted in calculus, according to Carnot's opinion, were nothing more than simplifications of the ancient method of exhaustion, which through them and in different ways was reduced to a convenient algorithm. Although Carnot's synthesis of the various methods had little success, the popularity enjoyed by the Reflexions helped to feed mathematicians a sense of dissatisfaction with those "abominable little zeros" of the infinitesimal analysis of the XVIII century and to prepare that need for rigor that will characterize the mathematics of the XIX century. Carnot was not the only one among the mathematicians of the French Revolution who felt the need for greater rigor in the field of mathematics. In fact, even Legendre[22].,, who was primarily a student of infinitesimal analysis, felt the need to seek mathematical rigor. The result of these efforts were the EIéments de géométrie, which appeared in 1794, the year of the Terror. Here, too, the theoretical aspects are dealt with, just the opposite of what are generally considered practical aspects; Legendre's goal, which he himself stated in the preface, was to present a geometry that satisfied esprit. Legendre's manual was extremely successful and constituted one of the mathematical works that came out during the Revolution which exerted the most profound influence: twenty editions were printed during the author's life. Legendre stated that his goal was to "compose a truly rigorous treatment of the elements" of geometry, but his need for rigor was not pushed to the point of making it a pedantic fetish at the expense of clarity of exposition.

4. Conclusions

So many were the developments and results of mathematical thought in the XVII XVI and XVIII centuries and they were such that they radically transformed the corpus of mathematics.

[22] Adrien-Marie Legendre (1752-1833) was a French mathematician. A disciple of Euler and Lagrange , he published a now classic work on geometry, Élements de géométrie. He also made significant contributions in differential equations, the calculus, the theory of functions and number theory with Essai sur la théorie des nombres (1797-1798), in 1782 he was granted the prize offered by the Berlin Academy for his bullet studies. He expanded his three-volume treatise Exercises du calcul intégral (1811 - 1819) in the new Traité des fonctions elliptiques et des intégrales eulériennes (1825 - 1832), again in three volumes. He then reduced the elliptic integrals to three standard forms, but their direct inversion, due to Abel and Jacobi, rendered his work useless. He also invented the Legendre polynomials in 1784 while studying the attraction of spheroids. In number theory, he also proved Fermat's last theorem in the particular case n = 5 and proved the irrationality of π^2

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Although the works of Euclid[23], Archimedes[24], Apollonio[25] and Diofanto[26], that is the works of the Greek classics, always remain an irreplaceable reference for the mathematicians of the centuries now considered, the innovations introduced by these scholars definitively shifted the center of research interests on arguments decidedly different from those of the mathematicians of antiquity, thus characterizing the research and studies of the following centuries.

In the XIV century Paris had been one of the scientific centers of the world (the other was Oxford), but it had long since lost this position. The University of Paris had lagged behind the times: when Europe had turned towards Cartesianism, it had remained anchored to the peripatetic scholasticism; and when most of the scientific world turned to Newtonianism, Paris fights a rearguard battle in favor of Cartesianism. In order to fully understand why France, the cradle of mathematics in the XVI and XVII centuries, recorded a real decrease in productivity in the XVIII century, we must examine both the historical and political situation. In XVIII century France, universities were not like today centers of mathematical studies, and it is difficult to mention even one mathematician of the century who carried out his activity at the university. Most of the XVIII century French mathematicians had relationships not with the universities, but with the church or the army, while others lived in the court of kings and princes or engaged in private teaching. This soon generated a waste of human resources, and the French mathematicians were unable to reach the pinnacle of a position commensurate with their abilities. The French Revolution contributed to further aggravate the already precarious situation of mathematicians; since France needed technical teaching to manufacture weapons, French mathematicians were forced to do so. In light of the above, we can conclude that, while the XVIII century was characterized above all by the pre-eminent interest in the collection of data and for the achievement of results and discoveries, which often corresponded to a rather approximate theoretical elaboration, the XIX century, on the other hand, as we shall see, the

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[23] Euclid (4th century BC - 3rd century BC) was an ancient Greek mathematician and philosopher. He dealt with various fields, from optics to astronomy, from music to mechanics, as well as, of course, mathematics. The "Elements", his best known work, is one of the most influential works in the entire history of mathematics and was one of the main texts for the teaching of geometry from its publication until the early 1900s.

[24] Archimedes of Syracuse (287 BC -212 BC) was a Sicilian mathematician, physicist and inventor. Considered as one of the greatest scientists and mathematicians in history, he contributed to advance knowledge in areas ranging from geometry to hydrostatics, from optics to mechanics: he was able to calculate the surface and volume of the sphere and intuited the laws that they regulate the buoyancy of the bodies; in the engineering field, he discovered and exploited the operating principles of levers and his very name is associated with numerous machines and devices, such as the Archimedes screw, demonstrating its inventive ability; still surrounded by an aura of mystery are the war machines that Archimedes would have prepared to defend Syracuse from the Roman siege. His life is remembered through numerous anecdotes, sometimes of uncertain origin, which contributed to building the figure of the scientist in the collective imagination. For example, the exclamation èureka ! Has remained famous over the centuries! attributed to him after the discovery of the principle on the buoyancy of bodies that still bears his name

[25] Apollonius of Perga (262 BC-190 BC) was an ancient Greek mathematician and astronomer, famous for his works on conic sections and the introduction, in astronomy, of epicycles and deferents. He was active between the end of the 3rd and the beginning of the 2nd century BC, but the scarce evidence of his life makes a better dating impossible and specific dates must be understood only in a purely speculative sense. It was Apollonius, moreover, who gave the ellipse, the parabola and the hyperbola the names with which these curves have been identified ever since.

[26] Diophantus of Alexandria was an ancient Greek mathematician, known as the father of algebra. Little is known about his life. Lived in Alexandria in Egypt in the period between the third and fourth centuries, some believe that he was the last of the great Hellenistic mathematicians. Diophantus wrote a treatise on polygonal numbers and fractions, but his main work is the Arithmetica, treated in thirteen volumes of which only six have come down to us. Its fame is mainly linked to two topics: indeterminate equations and mathematical symbolism.

XIX century, on the other hand, as we shall see subsequent paper, is characterized by the effort for the creation of unitary and rigorous theories, capable of providing a critically assessed and logically solid framework of the knowledge achieved in the various disciplinary fields. We can certainly conclude by stating that, even though mathematical thought has reached such a high degree of hyper abstraction today, mathematics continues to be the language of science, in constant evolution, just as it was for antiquity.

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