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Panorama of Studies on the History of Mathematics in Andalusia and the Maghreb Between the Ninth and Sixteenth Centuries

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Abstract— *This article sets out the norms for the study of the history of mathematics in Andalusia and the Maghreb between the ninth and sixteenth centuries. This article describes in general terms how the panorama of historical research in mathematics is taking shape. There is no doubt in the history of mathematics that it was the Arabs who developed mathematics. The method used by the author is library research. Literature research is research in which data collection methods are carried out by reading various literature related to information relevant to the research topic. In the region of Andalusia and the Maghreb, the history of mathematical research developed symbolic algebra, namely as modern arithmetic notation. Algebraic symbols were first developed by Ibn Al Banna, an Andalusian mathematician in the 14th century, then the symbols were modified by Al Qalasadi in the 15th century. From the various findings and the overall study, it is concluded that the research approach pursued by Muslim scientists to mathematics can be attributed to the phenomenological approach*.

Keywords— *History, Mathematics, Mathematics, Muslim*.

I. Introduction

The term "mathematics" is not something foreign to our ears, because mathematics has been present in all aspects of human life for centuries. Mathematics is a conductor and at the same time a source of solving any problems, ranging from problems related to the economy, politics, culture, society, religion, and others. Mathematics is also the mother of all kinds of science and its offshoots so that in every science we study we will meet mathematics. The word "mathematics" comes from the Greek "matema", which means knowledge, thinking, and learning (Nur Wahyu Eko Purnomo, 67-125-1-BC).

The history of the development of mathematics has been successful, but only in a few places since examples of the oldest mathematical writings that have been discovered are called Plimpton 322 (Babylonian mathematics circa 1900-1800 BC) and the Moscow Mathematical Bulletin (Mathematics of the Russian Federation). Egypt around 1890 BC). All of these writings discuss a theorem commonly known as the Pythagorean theorem, which seems to be the oldest and most widespread development of mathematics after elementary arithmetic and geometry.

However, the history of science has placed mathematics at the top of the scientific hierarchy (Fathani, AH, 2017). This is marked by many monumental discoveries of several Muslim figures and scholars that occurred during the heyday of Islam, such as Alcharism, Abu Hanifa Ahmad ibn Daoud (Al Dinawari), Ali ibn Robban At Tabari, Al Baktani Abu Abdillah, Al Kindi, Al-Karaji, Al-Biruni, Umar Khayyam, Ibn Sina. All of them made a great contribution to the development of mathematics, which eventually became the philosophical basis for the development of new branches of science in the field of agriculture, animal husbandry, medicine, economics, education, technology, and others. Therefore, mathematics is a very important subject in the education system in all countries of the world.

There is no doubt that it was the Arabs who developed mathematics. The discovery of the Arabs, was phenomenal, namely the concept of zero. The concept of zero provides unlimited convenience in the calculation process. Mathematicians consider zero to be the greatest invention known to mankind. When Muslims design the empty number (zero), they depict it as a circle with a dot as the center. In Masyrik (meaning Egypt and the Muslim countries to the east of it) they keep the dot (the center of the circle) and use it with their numbers: while in the Maghreb (i.e. the Muslim countries to the west of Egypt, including Andalusia), they maintain a circle without a center, i.e. a point (see, Mohamed, 2001).

At least in the history of human civilization, there are two roles of mathematics in the construction of civilization, according to Tolha and Barisi (2004), viz. First, the development of mathematics strengthens the dominance of science and technology in the development of creativity and productivity and allows people to engage in engineering, and facilitates the transfer of technology for the benefit and benefit of human life. Secondly, on the other hand, the strong dominance of science and technology has slowly displaced the noble values of the national culture that we uphold everywhere, causing massive alienation, especially in the social sphere (Tolha and Barisi in Nur Vahyu Eko Purnomo). 67-125-1-BC).

Based on the foregoing, mathematics develops in accordance with the development of human civilization. Therefore, it is very interesting to write a research panorama on the history of mathematics. Pay special attention to Andalusia and the Maghreb in the 6th-16th centuries AD. In this article, he will answer his research question, namely, how did the panorama of research on the history of mathematics in

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Andalusia and the Maghreb develop in the 6th-16th centuries AD?

Explain how the panorama of mathematical historical research in Andalusia and the Maghreb in the 6th to 16th centuries AD is described using theories and concepts of social change. This theory is very important for describing both processes and different approaches to the history of mathematics at that time. This means that theory and social change can describe the general history of the research question. In these theories and concepts, Comte and Weber will discuss social change in society.

Change is a continuous process that takes place in every society. There is a process of change that takes place in such a way that the inhabitants do not feel it. This movement of change is called evolution. Sociology describes the evolution of society from a simple society to modern society. The process of introducing this change into modern society falls within a range of objectives. A departure from Comte's theory of evolution about social change. Comte's starting point is his view of society using biological concepts that can be summarized (Martindale in Sihabudin, 2011, 17-18):

The first, society develops linearly (unidirectionally), that is, from a primitive society to a more developed one. Secondly, the evolutionary process experienced by society leads to changes that affect the change in values and various assumptions that society holds. Third, subjective ideas of value are mixed with the ultimate goal of social change. This is because modern society is a form of society that strives to have a better and more perfect label, such as progress and humanity. Fourthly, the social changes that take place from a simple society to a modern society occur slowly, without destroying the foundations on which the society is based, so it takes a long time.

According to Weber, the most decisive problem of modern life is the development of formal rationality. The formal justification that Weber had in mind involves the actor's thought process when choosing tools and goals. In this case, the choice is made taking into account generally applicable customs, rules and laws. All three come from various large structures, especially bureaucratic and economic structures. This state of rationality resulted in the iron cage of rationality. Humans are increasingly trapped in these iron cages and as a result are increasingly unable to display some of their most basic human traits (Nur, 2014: 7).

So the history of mathematics of the VI-XVI centuries. AD cannot be separated from the direction and changes that guide and accompany the progress of civilization. The panorama of mathematical research is a milestone in the change of civilization. Therefore, the conclusions of various early studies in mathematics became a condition for the development of time. Until today's social development, which has entered the era of the 40th industrial revolution, it cannot be separated from the various initial conclusions. The various innovations made today, such as startups or human activities, cannot be separated from digital media, and others are donations that will never end.

II. Research Methods

For this type of study, A Panoramic Study of the History of Mathematics in Andalusia and the Maghreb Between the Ninth and Sixteenth Centuries: A Study of Teaching Methods, the author uses library studies. Literature research is research whose data collection methods are carried out by reading various literature related to information and relevant to research topics (Sucardi, 2010: 34-35). Meanwhile, according to Lexi J. Moleong, literary research with field research uses a qualitative approach, namely studies whose procedures produce descriptive data in the form of written or spoken words from observed people and actors (Lexi J. Moleong in Fandi Ahmad, 2015: 147).

The type of literature research conducted is field research, the research uses a descriptive type, namely a detailed description of reality or phenomena by providing a critique or evaluation of these phenomena. The approach used by the author in this study is a historical approach. The historical approach is used to describe and study problems by collecting, compiling, analyzing, and refining existing data. Various sources of data in articles include journals, research reports, scientific journals, newspapers, related books, seminar results, scientific articles that have not been published, consultants, library letters, video graphics, and so on.

III. Results and Discussion

The history of the development of mathematics is inseparable from the Abbasid regime, which lasted five centuries from 750-1258. AD, continuing the rule of the Umayyad dynasty. Al-Saffah became the founder of the third Arab Islamic dynasty - after Khulaf al-Rashidun and the Umayyad dynasty, which was very numerous and long-lived. Under the Abbasid dynasty, not only mathematics, but also literature, philosophy, etc. developed. The age of science began when the second caliph of the Abbasid dynasty, Abu Ja'far al-Mansur (754–775), brought books from Greece (Serli Maloes, 2015: 79).

Caliph Harun al-Rashid, the fifth caliph of the Abbasid dynasty, was very concerned about the development of science. During his caliphate, which began around 786, there was a large-scale translation of ancient Greek mathematical (as well as other scientific) texts into Arabic. The next caliph, caliph al-Mamun, was even more concerned about the development of science; during his caliphate, the Council of Wisdom was created in Baghdad, which became the center for the study and translation of Greek manuscripts. To be good at scientific activity, you need tools in the form of language, logic, and mathematics (Kasmiati, 2006).

Various works and discoveries of Muslim intellectuals such as calculus, numbers, Algebra, Magic Cube games, mathematical induction and trigonometry.These various fundamental mathematical sciences were initiated and perfected by Muslim mathematicians (see Alifirisqotur Rohman, Gusti Ayu Arini, and Nurul Hidayah: 2015). The results of the study are described below.

Many Western scholars and historians recognize the enormous role of Islamic mathematicians as the guardians of

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world mathematics. In his book "Arab Hegemony", Boyer (1991) mentions that the period of the golden age of Islam may be the starting point in the development of mathematics in the world. This is because at that time there was a strong desire among the Arabs to study science, while in other parts of the world, efforts to study science began to wane. If Muslims do not rise up and become enthusiastic in the study and development of science, it is impossible to imagine how much ancient science and mathematics will be lost and destroyed by civilization.

Around 1000 AD, an Arab scholar named al-Karizimi found the calculation of integers to powers of three, or cubic equations. In the West, only Nicolò Tartalgia was able to solve this equation when he proposed a formula to solve it in the 16th century. For the services of al-Karizmi, a historian of Western mathematics, F. Wöckke called him "the first to introduce algebraic calculus (algebraic calculus)". Shortly thereafter, Ibn al-Haytsman succeeded in formulating a formula or formula for calculating the power of four, and developed a method for determining a general formula for calculating the power of every integer. This formula plays a very important role in the development of integral calculations (integral calculus).

Meanwhile, Almatic geometry, which is an important part of calculus, was first applied by Omar Khayyam in the 11th century. This Persian-born mathematician and poet multiplied analytic geometry to solve the equations of a cube using the diagram of a parabola intersecting a circle. A century later, another mathematician from Persia named Sharaf Addinat-Tusi discovered the derivative of the cube polynomial, which is an important discovery in differential calculus. Thanks to the merit of these Muslim scientists, craters on the Moon were named after them.

Undoubtedly, the development of arithmetic, which is a branch of mathematics, is a major contribution of Islamic civilization to the world. This branch of science, famous for numbers, reached its peak of development in the hands of al-Khwarizmi in the middle of the 9th century. Al-Khwarizmi's book "On the Account with Indian Numerals" (written about 825) and the book of al-Kindi entitled "Kitab fi Istimal al-Adad al-Hindi, or On the Use of Indian Numerals" (written about 830), are the first two sources that played an important role in the introduction of the number system from India to the Middle East and West. From our culture today, we know the numbers 1, 2, 3, 4, 5, 6, 7, 8, and 9 (which are now known as Arabic numerals in English).

This Arabic numeral was used in Baghdad in the 8th century AD when a scholar from India introduced the Indian numeral system in 771 AD. dot (comma) as a fraction marker. The calculation of this model is described in a treatise by a Syrian mathematician named Abdul Hasan al-Uklidisi, written in 952-953. In the Arab world itself, until the present, Arabic numerals are used only by mathematicians. Other Muslim scholars prefer the Babylonian system, and merchants use Arabic alphabet numbering. A slightly different variety of "Western Arabic" numeric characters began to be widely used around the 10th century in the regions of the Maghreb (North Africa) and Andalusia (Islamic Spain). Numbers similar to modern Arabic numerals are called Gubbar numbers meaning "sand table or dust table".

In the West itself, the Arabic numeral system is first mentioned in a manuscript called Godex Vililanus, written in Spain in 976. From the 980s, Herbert Orilaksky began to use the number system in Europe, where he subsequently received many rejections for bringing new and strange knowledge from the Islamic world. Herbert did study in Barcelona when he was young, and it is possible that he also studied Islam in Andalusia. Since then, the Arabic numeral system has been used in Europe instead of the Roman numeral system. The world owes much of this to the work of al-Khwarizmi with his book Calculations with the Indian Numeral System. This book was later translated into Latin under the title Algoritmi de Numero Indorum.

Mohammad bin Musa al-Kharizmi (780 AD) was the main figure behind the birth of the branch of algebra. This mathematician working for the Baitul Hikma Company in Baghdad clearly articulates the concept of using numerical symbols in equations in his book Al-Jabr wal Mugabalab Risala, or A Brief Review of Calculation with Solutions and Equations. This book was translated into Latin under the title Liber Algibrae et Almucabal by Robert of Chester (Segovia, 1145) and also by Gerard of Cremona. It is from the title of the book of al-Khawarizi that we got the word algebra, which is still used today.

The treatise is divided into six chapters, each chapter discussing a separate formula or equation formula. The first chapter of al-jabr deals with equations in powers of two equal to their roots (ax2=bx), the second chapter deals with equations in a cube equal to a number (ax2=c), the third chapter deals with equations with roots equal to a number (bx = c), the fourth chapter deals with the square of the equation equal to the roots of the number (ax2 + bx + c), the fifth chapter gives the equation to the power of two and the numbers equal to their roots (ax2 + c = bx), and the sixth and final chapter is devoted to the roots and numbers equal to powers of two (bx + c = ax2).

Algebra is the process of removing negative ones and getting the same root on both sides. For example, x2 = 40x - 4x2 can be simplified to 5x2 = 40x. Algebra has succeeded in becoming the number one theory, which allows you to measure numbers, numbers cannot be measured, and other elements are likened to "objects that can be studied with the help of algebraic science." Since al-Khwarizmi wrote his Algebra, modern mathematics has never been different from the obsolete ancient Greek mathematics. Algebra was later re-developed by the Persian mathematician Omar Khiyam (1050–1123). He managed to solve the equation of a cube using the corresponding numerical solution using trigonometric tables.

This fact also refutes the claim that the first person to apply algebra was the French mathematician François Vieta (1591). He is said to have used x and y in his algebra book to express equations in literal symbols. In fact, the use of this model equation is purely a discovery by Muslim mathematicians. The variable x, for example, is a simplification of the character for the Arabic letter "siyin".

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The proof is that Xavier is still pronounced Syavier and Xanana is still pronounced syana. Negative numbers themselves were widely used by Islamic mathematicians in arithmetic 400 years before they were used by Geronino Cardano of Italy in 1545.

Mathematical games were known to Arab mathematicians in the Middle Ages. For example, the magic cube game from the 7th century AD, just after they came into contact with the cultures of India and South Asia. These Muslim scholars then studied Indian mathematics and astronomy, including other branches of complex mathematics. The first type of magic cube known to some Islamic mathematicians with an arrangement of 5 or 6 small cubes was described in an encyclopedia from Baghdad around 983 CE.

The first recorded attempt at mathematical induction in history was made by al-Karaji around the year 1000. He used it to prove the existence of arithmetic series such as the binomial theorem, Pascal's triangle, and formulas for computing cubic integrals. The proof he found was the first calculation that used the two main components of an inductive proof, namely the statement that "n = 1 (1-13) and n = k is proved true if n = k-1". Shortly thereafter, Ibn al-Haytham used the inductive method to prove the result of a power of four, and then proved the result of the power of all integers. This calculation is a very important achievement in the field of integral calculus.

In his book Analysis and Synthesis, Ibn Haytham discovered that every even integer represents the equation 2n-1 (2n - 1), where 2n - 1 is a prime number. Unfortunately, he was unable to prove the results of his calculations. Euler managed to calculate this proof only in the 18th century. The discoveries of Ibn Yahya al-Mahghribi al-Samaw'al are even close to the discoveries of modern mathematics before modern times. He used this discovery to extend the proofs for calculating the binomial theorem and Pascal's triangle, which were discovered earlier by al-Kharizmi.

It cannot be denied that the science of the shapes and angles of triangles is one of the greatest contributions of Islamic scholars to world mathematics. The concept and uniqueness of this triangle were known to the ancient Greeks, but the development of trigonometry to the extent that it can confuse schoolchildren as it is today is entirely the work of medieval Islamic scholars. Even the words sin, cos and tan come from Arabic.

According to historical records, Muslim scholars from Arabia and Persia studied trigonometry after translating mathematics books from India. They then developed further before spreading the knowledge of trigonometry throughout the Islamic world. The most successful figure in this respect so far belongs to al-Khwarizmi, who wrote tables of sines and tangents and developed trigonometric tables of spherical shapes. In the 10th century, in the book of Abu al-Wafa, Islamic scholars used six trigonometric functions, which are provided with a table of sines with a difference of 0.25 degrees and an accuracy of eight decimal places. He also developed the trigonometric formula sin 2x = 2 sin x cos x, which is still taught by math teachers today.

Al Jayani of Andalusia wrote the first treatise on spherical trigonometry in his book on the unknown curvatures of spherical shapes. The book contains formulas for right triangles, general sine laws, and formulas for calculating a triangle with rounded corners through the most opposite triangle. Meanwhile, Jayadi's definition of ratios as numbers and his method of solving calculations for spherical triangles whose three sides are unknown seem to be very influential. In addition, Muslim engineers were also the first to develop a triangulation method not yet known to the ancient Greco-Roman world for surveying.

Thanks to the various studies and discoveries of these Islamic mathematicians, they became part of the general development of the history of mathematics in the regions of the Maghreb and Andalusia, as well as throughout the world. The main heritage of mathematics will always be remembered by the whole civilization. In the 19th century, the demand from industry and trade became more and more, so mathematics began to develop, and since then, mathematical education has become very important and necessary.

Mohamed (2001) wrote that the Maghreb region consists of Muslim countries in the west of Egypt, including Andalusia. Al-Maghrib itself is the classical name for the territory of the kingdom, which includes Morocco, Libya, Algeria, Tunisia and Libya. The country is indeed located on the western tip of the African continent. From an Arab point of view, especially for Morocco, this country is in the "far west (Al-Maghrib-Al-Aqsa)", projecting a little further west than Al-Andalusia in Spain. Leading Muslim mathematicians have contributed to the history of mathematics in this area. Especially various mathematical concepts that are specifically discussed in this section, namely the discoveries of symbolic algebra.

Algebraic symbols were first developed by Ibn Al Banna, an Andalusian mathematician in the 14th century, then the symbols were modified by Al Qalasadi in the 15th century. In Al Banna's Talhis A'mat al-Hisab, a fraction is defined as a relationship between two numbers to represent one or more parts. The relation between a part and a number leads to the same name and is called a fraction. Al Qalasadi then developed Al Banna's work, he put the numerator over the denominator and separated them with a horizontal line. The reason is that for Al-Qalasadi, the faction was something new at the time. To explain the fraction, Al-Qalasadi then uses the statement "ala ma'sihi" which means "to place on it" and "

Calasadi is mentioned in many historical records as the first person to use the algebraic symbols that are now used when writing equations to represent fractions, as well as the first scientist to use symbols when discussing and writing mathematical equations. Adam Malik Khan in "Al-Qalasadi: The Eminent Mathematician of Muslim Spain", Islamic Studies, explains how Kalasadi uses mathematical symbols using Arabic letters. It uses "Va" which means "And" for addition (+), then "Laa" represents subtraction (-), "Phi" for multiplication, and "ala" for the division symbol (/). In addition, it also uses the character "j" to represent the root. "Shay" represents a variable (x), "m" represents a square (X2), the letter "k" represents a power of three (x3), and finally "I" as a symbol for equality or equality (=) (Tirto, 2017).

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The symbols were also later developed by scientists from Europe. For example, the addition symbol allegedly did not appear in the 15th century, but only the subtraction symbol was already used in the work of Leonardo Fibonanci in 1202. In fact, the addition symbol was discovered in the Regiomontanus manuscript in 1456. Then the addition symbol appeared in England in the book Ground Of Artes and was recognized only from 1630. Julio Samso Moya, professor emeritus at the University of Barcelona, once wrote that 19th century writers believed that algebraic symbols were first developed in Islam by a Muslim, including Ibn Al Banna. and Al Qalasadi. Moya mentions the lack of mathematical symbols in Italy, for example,

Manuela Marin in The Making of a Mathematician writes, Al Qalasadi spends most of his time in North Africa and Tlemcen, an area in northwestern Algeria near the Moroccan border. In this place, he learned a lot about arithmetic and its applications. It was here that Al Qalasadi then developed Ibn Al Banna's discoveries of algebraic symbols. He has written many books on arithmetic and algebra, some of which contain commentaries on Ibn al-Banna's work titled "Talhis Amal al-Hisab" ("Summary of Arithmetic Operations") (Manuela Marin in Tirto.id: 2017).

One of the titles of his books that borrow Al-Banna's thinking is At-Tabsira film al-Hisab (Explaining the Science of Counting). Although Al-Qalasadi has simplified it, this book requires sharpness of mind from those who study it. This book is also one of the most difficult books for most people to read. Al Qalasadi, in addition to being known as the "Professor of Algebra", he was also the first to write a book explaining the rules of algebra in poetry. In addition, he also wrote nine books on the grammar and traditions of the Prophet Muhammad, and his knowledge was later passed on to Abu Abdullah Al Sanusi. He is one of Al-Qalasadi's protégés who has managed to produce 26 works in mathematics and astronomy that are recognized as authoritative texts throughout North Africa (Tirto, 2017).

The magnitude of this contribution is described as so extraordinary that it is said that we cannot understand the development of modern mathematics without the mathematics developed by Muslim mathematicians.

The unique view of Muslim scholars on mathematics can be seen in the phenomenological approach of this school, pioneered by Edmund Husserl (1859-1938). However, the phenomenological view is indeed widely used in the social sciences of man. There is a phenomenological statement that deserves to be a link in the understanding of mathematics by Muslim scientists. According to Richard Smith in Husain Hariyanto (2011; 225), namely (1) ab initio); (2) descriptive; and (3) Providing phenomena that describe awareness. Should have different meanings, awareness and intentionality are two basic terms that are inseparable in the phenomenological method. From a phenomenological point of view, awareness of the subject is intentional, that is, open and directed to objects outside the subject.

Awareness of the subject correlates with object reality because awareness is intentional and reality is self-evident. Consciousness is open and directed towards the object. There is no subject without an object and vice versa. Thus, mathematical phenomenology is a survey of the relationship of man as a subject with mathematical principles as objects. The type of relationship that is built in mathematics is that mathematical truths are tautological, namely, truths that are closed without correlation with the consciousness of the subject or the phenomena of the universe. Then mathematical relations are relational, correlate with objective consciousness or natural phenomena. Muslim scholars believe that mathematical principles are not something alien and isolated from reality.

IV. Conclusion

Muslims need to participate in the development of science and mathematics, including the improvement of the basic structure, as was done by previous thinkers. The panorama of mathematical research during the 6th to 16th centuries in the Maghreb region and Andalusia or the Arab region, in general, has become an integral part of the continuity of the history of science and mathematics or of human civilization itself. Specifically, symbolic algebra was coined as: modern arithmetic notation. Algebraic symbols were first developed by Ibn Al Banna, an Andalusian mathematician in the 14th century, then the symbols were modified by Al Qalasadi in the 15th century. The exploratory approach taken by mathematicians is an Islamic treasure that cannot be ignored. Muslims should always participate in the development of science and mathematics by doing research that benefits society. Because the scientific activity is the duty of the human caliphate on earth. Muslim scholars should contribute to religion in the form of technical assistance to improve the application of religious teachings, this is intended to rethink our view of science, especially science and mathematics.

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