The impact of scientific knowledge and Islamic mechanical inventions upon the structural composition of Islamic Designs During the century (7-8 AH /13-14 AD)

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Abstract:

Through intellectual and cognitive advancement related to science and the arts, which complement one another, the renaissance of ancient civilizations and the foundations of those civilizations have been strengthened throughout time. The more technological sciences advancement, the more flourished are patterns, and techniques of art production, as both science and art, stem from human nobility. The jurists of Islamic law were distinguished by their mastery of natural and experimental sciences, and they invented many mechanical structures such as clocks and observatories, and the most famous of them were (Al-Khawazmi, Ibn Rushd, Al-Qarafi, Al-Mazari, Ibn Al-Nafis, and other scholars. Islamic arts were not far from technological development, especially since they are characterized by flexibility, functional integration, and their scientific and mechanical heritage. One of the goals of Islamic civilization is the building of the earth as commanded by God the Almighty and His Messenger Muhammad, may God bless him and grant him peace. Therefore, it always strives for the continuity of human learning and the preservation of the past, present, and future.

The importance of the research lies in pioneering the innovations of Muslim scholars who contributed to laying the foundation of mechanical sciences. These inventions stimulated the mind and imagination of the contemporary artists of Islamic manuscript schools of that historical period during the two centuries (7-8 AH/13-14 AD) producing illustrations with philosophical dimensions. Forming the beginning of the imaginary virtual worlds, which stirred consciences, and minds without deviating from the general characteristics of Islamic arts.

The study aims to analyze the impact of the discovery of the science of algorithms on the development of the philosophy of designing the arts of Islamic manuscript schools during the two centuries (7-8 AH/13-14 AD), which in turn excelled in creating constructive structures with emotional and mental dimensions. The research problem includes the impact of experimental sciences, especially the science of algorithms, on changing the vision and design of Islamic manuscripts. How did painters of manuscripts of Arab schools mold their imaginations, get inspired by stories, anecdotes, and historical recordings, into a virtual world of their own, in which they roam and almost touch without prejudice to the rules followed in Islamic jurisprudence? The study is following the historical and descriptive-analytical method, it concluded that there is a reciprocal relationship between the prosperity of science and knowledge in the light of achieving the prosperity of the state political and economic rules, which in turn was reflected in the thought, conscience, and mind of the artistic craftsmen of the schools of Arabic manuscripts. This resulted in a general development in the elements and their design and the creation of new in-depth visions as if it expresses hidden worlds that the Holy Qur'an and the noble Sunnah of the Prophet spoke about, as well as historical events and

scientific and practical experiments. This calls for the importance of re-studying the ancient cultural heritage with an in-depth analytical perspective to open the fields of artistic and technical creativity to create new artistic trends with heritage roots to preserve identity and heritage.

Keywords:
the art of drawing Islamic manuscripts; Arab manuscripts schools; Mongol school

الملخص :
نهضة الحضارات العريقة ورسخت دعائمها علي مر العصور من خلال التقدم الفكري والمعرفي المرتبط بالعلوم والفنون فهي علاقة تكاملية. كلما تقدمت العلوم التكنولوجية ازدهرت أنماط وتقنيات إنتاج الفنون فكلاهما ينبعان من النبل الإنساني. تميز فقهاء الشريعه الإسلامية بإتقان العلوم الطبيعية والتجريبية، وابتكروا العديد من التراكيب الميكانيكية مثل الساعات والمراصد وكان أشهرهم (الخوازمي، وابن رشد، والقرافي والمازري، وابن النفيس وغيرهم من العلماء. لم تكن الفنون الإسلامية في منأي عن التطور التكنولوجي، وبخاصة أنها تتميز بالمرونة والإندماج الوظيفي، كما انها صاحبة الإرث العلمي والميكانيكي. فمن أهداف الحضارة الإسلامية عمارة الأرض كما أمر الله تعالي ورسوله محمد صلي الله عليه وسلم، لذا تسعي دائماً إلي إستمرارية التعلم الإنساني والحفاظ علي الماضي والحاضر والمستقبل. تكمن **أهمية البحث** في ريادة إبتكارات العلماء المسلمين الذين ساهموا في وضع أساس العلوم الميكانيكية، وقد دفعت تلك الإختراعات إلي تحفيز ذهن ومخيلة فناني مدارس المخطوطات الإسلامية المعاصرين لتلك الحقبة التاريخية خلال القرنين(٧-٨هـ/١٣-١٤م) منتجين رسوم توضيحية ذات أبعاد فلسفية، مشكلين بداية العوالم الإفتراضية التخيلية مما أثارة الأذهان والوجدان والعقول دون الخروج عن الخصائص العامة للفنون الإسلامية.
تهدف الدراسة إلي تحليل أثر اكتشاف علم الخوارزميات علي تطور فلسفة تصميم فنون مدارس المخطوطات الإسلامية خلال القرنين (٨-٧هـ/١٣-١٤م) والتي بدورها أبدعت في إبتكار تراكيب بنائية ذات أبعاد وجدانية وعقلية. تضمنة **مشكلة البحث** أثر العلوم التجريبية وبخاصة علم الخوايرزمات علي تغيير رؤي وتصميم رسوم المخطوطات الإسلامية. كيف أصاغ رسامي مخطوطات المدارس العربية مخيلاتهم المستلهمه من القصص والحكايات والتسجيلات التاريخية إلي عالم إفتراضي خاص بهم يجوبون به، ويكادوا أن يلمسوه دون المساس بالقواعد المتبعه للفقه الإسلامي. وقد توصلت الدراسه من خلال إتباع **المنهج** التاريخي والوصفي التحليلي إلي **نتائج** أنه هناك علاقة تبادلية بين إزدهار العلم والمعرفة في ظل تحقيق إزدهار حكم الدولة سياسياً وإقتصادياً، والذي بدوره أنعكس علي فكر ووجدان وعقل أصحاب الصنائع الفنية لمدارس المخطوطات العربية؛ مما نتج عنه تطور عام في العناصر وتصميمها وإبتكار رؤي متعمقه جديدة، وكأنه يعبر عن عوالم خفية تحدث عنها القرآن الكريم والسنة النبوية الشريفة، وكذلك الأحداث التاريخية والتجارب العلمية والعملية. مما يدعوا إلي أهمية إعادة دراسة التراث الحضاري القديم بمنظور تحليلي متعمق لفتح مجالات الإبداع الفني والتقني لإبتكار إتجاهات فنية جديدة ذات جذور تراثية للحفاظ علي الهوية والتراث.

الكلمات المفتاحية:
فن رسم المخطوطات الإسلامي؛ مدراس المخطوطات العربية ؛ المدرسة المغولية

Previous studies:

Manifestations of Liberation in Islamic Painting from the Umayyad Era until the End of the Safavid Era, Mahmoud Morsi Muhammad Al-Jarhi, Journal of the Arab Society for Islamic Civilization and Arts, Issue No. 7, 2017. The study deals with the influence of the Sassanian and Byzantine arts in editing the elements of the topics of Arabic manuscripts during the century (7-12 AH/13-18 AD), and linked it to the stage of political and geographical rule. Especially the penetration and spread of the Persian culture, which cast a shadow over the drawings of the manuscripts of the Mughal, Muzaffari, Jalayari, Timurid, and Safavid eras. He also referred to the artist's revolution and his rebellion against the anti-established traditions of freedom of artistic creativity. The dialectic of the real and the imaginary in Islamic miniatures, Hassan Hadi Abd al-Kadhim al-Ghazali, Journal of the College of Education for Girls for Human Sciences, University of Kufa, Volume 12, Issue 22, 2018. The study deals with the art of analyzing miniature drawings as one of the means of expressing the essence of the inner spiritual existence that is difficult for the senses to comprehend. He also dealt with the Muslim artist transcending inherited artistic concepts and adapting them in a way that is compatible with the spirit of the age and values of Islamic religion. The researcher dealt with the topics of miniatures related to religious, scientific, and literary topics during the centuries (7-10 AH / 13-16 AD) implemented in its civilized and cultural centers such as the Arab School in Baghdad, the Persian, the Ottoman, and the Indian. The researcher concluded by dividing it into what is realistic that can be perceived mentally and theoretically as a Muslim in his presence, and what is imaginative and emotional stemming from human thought, which enriched the methods of Islamic miniature schools, where historical events were depicted as well as stories of prophets, angels and some literary figures. The folklore epic stories also contributed to more freedom in realistic and imaginary depiction.

Some studies dealt with the engineering elements arising from mathematical algorithms and they are based on relative relationships in designs according to specific aesthetics that were constantly followed in the arts of architecture and applied arts, but they did not adopt the study of the impact of algorithms and mechanical inventions on the rhythm of designing the art of manuscript graphics in Islamic schools.

Research Problem:

- The impact of experimental sciences, especially the science of algorithms, on changing the vision and design of Islamic manuscripts.
- Monitoring the stages of the development of the art of manuscript graphics in terms of objective liberation and the components of constructing the graphic work.
- How did the makers of manuscript drawings create a special spiritual virtual world without prejudice to the rules of Islamic jurisprudence?

Research Questions:

-What is the impact of the integration between art and experimental sciences on changing the thought and methodology of the painters of Islamic manuscripts?

- Did the movement of mechanical inventions of Muslim scholars affect design and objective thought in the art of illustrated manuscripts during the period from (7-8 AH / 13-14 AD)?
- Did the makers of manuscript drawings innovate constructive engineering relationships to design and distribute the elements?

Importance of the Research:
- The complementary relationship between science and art in light of the inventions of Muslim scholars.
- Analysis of some models of illustrated manuscripts that reflected the dynamic and linear development in design thought.
-Studying the impact of algorithms and mechanical inventions on the rhythm of designing the art of manuscript graphics in Islamic schools

The research limitations:
Spatial limits: Baghdad - Egypt - Syria - Iran (according to the origin of the manuscript)
Temporal boundaries: Arab schools during the 7-8th centuries AH / 13-14 AD.

Research aims:
- Algorithms influenced architecture and its elements, resulting in different styles of decorations and their derivatives, and thus affected the art of designing and drawing manuscripts for Arab schools and gradually changed their concepts, especially that Islamic arts meet on their unity.
- The originality and flexibility of the elements of Islamic arts helped to ease familiarity with the developments in the production of experimental sciences.

Research hypotheses:
- The discovery of the theories and applications of mechanization led to the famous scientist Al-Khwarizmi and Muslim scholars to the creation of engineering systems that were employed to facilitate the process of building and work to serve it, and this is from the construction side. Tools were also developed for the manufacture of applied arts and their decorations. It is expected that these innovations will be reflected in the composition of the design elements of Islamic illustrated manuscripts.
- Islam's prohibition of drawing living creatures led to the enrichment of the art of engineering structural design in the drawings of Islamic manuscripts schools.
Research terms: - What are algorithms and related terms?
Algorithm: It is named after the Arab Muslim scholar Abu Jaafar Muhammad ibn Musa al-Khwarizmi who discovered it in the 6-7 AH / 12-13 AD century. It is a group of logically sequential mathematical steps to solve a problem. It means in its origin three elements (sequence, selection, and repetition).
The art of miniatures: in the Arabic language, the singular is miniature, i.e., etching and decoration, and it is the accurate depiction that decorates a page or some pages of a book[1]. He also defined the art of miniatures as "traditional Islamic and Arab art in which images of shapes

appear in miniature sizes in proportion to the size of the page of the book in which it is contained. [2"]

Research Methods: Historical and Analytical Descriptive Approach

Study Samples: *Manuscript samples were selected on the basis of:*

1. Tracking the movement of liberating design elements from (lines, shape, block formation, colors).
2. The diversity of topics and their departure from the traditional idiomatic character.
3. The method of distributing and configuring the elements on the basis of engineering and iterative succession.
4. Illustrated manuscripts that contain some of the inventions invented by Muslim scholars.

Historical introduction:

Science has been linked to civilizational progress over time, and in order to read and analyze the creations and developments of Islamic art, we must follow the development of engineering mathematical sciences that contributed to the consolidation of the initial structure of the creations of artistic crafts makers during the successive eras of Islamic civilization. Like the civilizations that preceded it, Islamic art was influenced by several factors, including religious, jurisprudential, political, environmental, economic, and other factors. Among the important factors that affected its formation were the scientific inventions that cast a shadow on its industrial and design techniques.

Since the dawn of history, mankind has been interested in the development of life, then many discoveries followed to facilitate the tasks of life. Ancient civilizations that used the sexagesimal system, such as the Sumerian, Assyrian, and particularly the Babylonian (2100 BC), have existed since prehistoric times. [3]. The ancient Egyptian civilization developed the arithmetic system, innovating the decimal system, by finding complex engineering solutions to calculate areas, especially those related to agricultural lands, as well as calculating the sizes of different blocks, which led to advancing the wheel of experimental science. With the beginning of the establishment of the dynastic era in the ancient Egyptian era (3200 BC - 2560 BC), science and industrial technologies made remarkable progress, especially during the reign of King (Mina) who unified the two countries. Schools known as (the cycle of life) joined the building of temples that specialized in studying the techniques of science, establishing the first advanced scientific civilizations. This engineering knowledge was reflected in the products of the art makers, as they realized the calculations of the geometric blocks and their sizes, and they built many types of buildings and decorated them with sculptures and wall inscriptions. The employment of engineering sciences exceeded the limits of building and decorating, as it was used to consolidate the religious belief of peoples by moving three-dimensional statues in mechanical ways based on the force of water or air or invisible threads through temple priests, and the first model of a three-dimensional wooden statue of a woman (945 BC -664 BC) was found. [4]. It is believed that it was used for a religious or magical purpose. These moving figures were also used by ancient peoples, such as the Chinese, as entertainment for rulers.

The Greek civilization continued the march of mathematical sciences in the 7th century B.C., where the Greek scholars learned from the civilizations that preceded them those experimental

sciences and formulated them theoretically and philosophically. It is believed that the father of Greek sciences is Thales of Miletus (c. 624/623 – c. 548/545 BC) who studied in both (Egypt and Babylon), Thales drew engineering, architectural and astronomical sciences from those ancient civilizations. In the 6th century BC, the status of the Greek sciences was elevated by the hands of a group of scholars, the most famous of whom was Pythagoras, who was called the father of mathematical sciences and described the number as the origin of all things. Greek Hellenism until the departure of (Aristotle), however, this stage laid the foundations for the "cognitive theory of mental inference and the concept of the scientific method. "[5]

The efforts of the Greek scientists culminated in the theories of (Plato) in the 4th century BC, when he linked the engineering and astronomical sciences, considering mathematical and engineering sciences as the basics of other sciences. He also renewed the methods of scientific and philosophical research separately. Then the progress of mathematical and engineering sciences continued over the course of the two centuries (5th and 4th BC) at the hands of (Hippocrates (c. 460 BCE- c. 375 BCE), Socrates Plato (c. 470 BCE- 399 BCE), Archimedes (287-212 BCE) and Aristotle (428/427 BCE - 348/347 BCE) and the genius Soranus of Ephesus (1st/2nd century AD)[1] the Egyptian-Greek in the city of Alexandria. They were followed by the pioneer of the scientific renaissance in Alexandria (Euclid) in the 3rd century BC. The Ptolemaic rule (323-30 BCE) in Egypt lasted for nearly three centuries, but the city of Alexandria had an abundance of distinguished scholars such as Aristotle (384 BCE - 322), Epicurus (341 c- 270), Arête of Cyrene (c. 400 BC–c. 340 BC), Hypatia (c.355 ce-415), Euclid (325 BC-265 BC), Archimedes (287-212 BCE), Apollonius Peerages (c. 240 BCE/BC – c. 190 BCE/BC), and others). The conquests of Alexander the Great (332 BC) contributed to the exodus of scholars from Athens to the city of Alexandria, while they migrated again from Alexandria to (Syriac) city of Edessa in Asia Minor, to avoid Byzantine religious persecution, and from here the city (Edessa) became the meeting point between Greek sciences and Arabic sciences in the city of Baghdad.

The Library of Alexandria Museum, the reigns of Ptolemy I (323-285 BC) and Ptolemy II (309-246 BC) are witnesses to the codification and documentation of these experimental sciences, as they were burned in the year (48 BC) due to the participation of "Julius Caesar in the Alexandrian war between the two brothers contended for the throne"[6], However, Antonius rebuilt it and brought books from the Pergamum Library from Asia Minor, the era of (Cleopatra).

During that historical period, there were many scientific setbacks, some of them were political and others religious and doctrinal, which eliminated the scientific repertoire that the Library of Alexandria contained, and it was finally eliminated under Byzantine rule, which led to the migration of scholars from Egyptian lands and Athens to Asia and Baghdad during the Abbasid state.

Egypt came under the rule of the Roman Empire during the second century AD, and the city of Alexandria enjoyed a great deal of international scientific standing. Pelops of Alexandria is considered the most famous and most important scientist in Athens and Alexandria, due to the multiplicity of his books in the third or fourth century AD, where he collected and summarized all the theories of the scholars who preceded him, extracting scientific, analytical, and

mechanical engineering theories. Over the course of that science, engineering, and astronomical march, the Greeks and Romans realized that artistic philosophical theories are linked to engineering and mathematical sciences, which resulted in what is known as the Golden Ratio (rectangle/triangle/pyramid) that was applied to all types of arts and their raw materials. Which gave a sense of balance and interdependence between the design elements in a proportional manner, and it was later known as the (Fibonacci Sequence).

Muslims were keen on teaching, learning, and acquainting themselves with all the tributaries of science with great care, following the example of the first of the divine mandates in Surat Al-Alaq in the Noble Qur'an that was revealed to the Prophet Muhammad (may God bless him and grant him peace) "Read in the name of your Lord who created (1) He created man from a clot (2) Read, and your Lord is the Most Generous (3) Who taught with the pen (4) He taught man what he knew not (5)[7]" Then the Prophet, may God's prayers and peace be upon him, urged Muslims to read and write, during wars he offered to spare the captives if they teach Muslims reading and writing, which contributed to spreading the true doctrine of the Islamic religion.

The star of Muslim scholars emerged in all sciences during the two centuries (6-8 AH / 12-14 AD), when they reached an experimental scientific approach based on induction and experiment based on evidence, evidence and experience, and one of the pioneers of this approach was Abu Musa Jabir bin Haiyan, the chemist (101-199 AH / 721-815 AD), and Abu Abdullah Muhammad bin Musa Al-Khwarizmi (164-232 AH / 781-846 AD) a mathematician, astronomer and geography who took this knowledge from the Greeks, then took from the Indians (Sanskrit - Devanagari) (Gobar numbers), which was brought by one of the Indian astronomers during the reign of the Abbasid Caliph Abu Jaafar Al-Mansur in the year (154 AH / 771 AD) - which is used today in the Arabic language, and Al-Khwarizmi added to them the number (zero) as he drew it on the basis of the number of angles (right and acute) that the number contains, also in pneumatic numbers in the year (210 AH / 825 AD) or the decimal system, as Abu Ali Al-Hassan bin Al-Hassan bin Al-Haytham Al-Basri (354-430 AH / 965-1040 AD) developed analytical geometry, the foundations of calculus, the founder of the scientific method, and the inventor of the device (Al-Qumrah) to prove the physical nature of light.

Ghiyath Al-Din Abu Al-Fath Omar ibn Ibrahim Al-Khayami (408-517 AH / 1040-1131 CE) established the beginning of algebraic geometry, solved the cubic equation, and was the first to recognize irrational numbers as real numbers. Abu Jaafar Muhammad bin Muhammad bin Al-Hassan Al-Tusi (597-672 AH / 1201-1274 AD) invented the first techniques of Euclidian and Muslim parallel geometry, and recorded the first law of conservation of mass, given that the body of matter is not subjected to change, but it cannot annihilate, with many other Arab Muslim scholars.

Historical studies are related to all sciences, including natural sciences. The foundations of the history of science were laid by Al-Hassan Ibn Al-Haytham (354-430 AH / 965-1040 AD), who traced the development of the history of scientific issues, writing down all the steps and revealing the methods that were handled by previous scholars. These scientific inventions in the Middle Ages accomplished many tasks that were previously dependent on the human factor in the ages that preceded the emergence of Islam and were replaced by innovative mechanical machines without fully relying on effort, thus resulting in successive industrial revolutions

through the ages, the problem of aspects of civilizational development to this day. These mechanical and engineering innovations were contemporary in successive times with the manufacture of illustrated manuscripts, which contained many illustrations that illustrate their inventions and the stages of their functional performance, as well as their tools.

The relationship between science and human mental perception of the Holy Quran:

The verses of the Holy Qur'an always tell us about the stories and miracles of God and how He created the universe, which prompts man to think and ponder and link science and religion. Islam is a religion of monotheism, as it is the basis of the integrative vision that combines thinking with the human mind, the responsibility of feeling his senses and his spirit and studying the universe and nature, so he can combine matter and spirit, rights, and duties, privacy and public, this world and the hereafter. How many Qur'anic verses entrust man with the continuity of scientific progress, deep, insightful, and honest thinking about the existence of the phenomena of God's creation in the universe and the nature that surrounds it, and realizing the unity of the universe that indicates the unity of the Creator within the framework of man's cognitive shortcomings of knowledge, except a little." (Surah Al-Israa, 85)[8]. This opens the way for knowledge continuity on humane and ethical grounds, which are among the necessities of succession and humane civilization. From here, the feature of moderation, non-alignment, and synergy between the various natural sciences is formed under the empirical approach, which is the creative, rational, critical thinking method.

The image of many scenes in the Holy Qur'an illustrates and shows the development in the industry and the aesthetic scene, for example, "She was told, "Enter the palace." But when she saw it, she thought it was a body of water [1077] and uncovered her shins [to wade through]. He said, "Indeed, it is a palace [whose floor is] made smooth with glass." She said, "My Lord, indeed I have wronged myself, and I submit with Solomon to Allah, Lord of the worlds".[9] Surah Al-Naml verse (44) Here is the scene of Bilqis, the Queen of Sheba, who revealed her legs, thinking that she would wade into the water (the loggia) to reach the crystal palace erected above the surface of the water of our master Solomon, peace be upon him, as well as God Almighty's constant reminder of the balance of the universe and the movements of the stars, the moon, the sun, and His creation for the human being in the best evaluation, and also the Almighty referred to the various industries such as textiles and the importance of the iron industry, food, and medicine, the manufacture of pearls and corals, sailing, transportation and other scientific knowledge and innovations related to mental pictorial beauty.

Despite the prohibition of Islam on drawing living creatures, especially at the beginning of the golden age of the Prophet Muhammad, may God bless him and grant him peace and the Rightly Guided Caliphs, with the aim of consolidating the Islamic faith in the conscience and minds, we find many narrations about the Messenger that do not contain abuse against drawings, sculptures, and drawings were found dating back to the Umayyad era, in the palace of Khirbet al-Mafjar, Qusayr Amra, and others of the Umayyad caliphs. The three stages of Samra decorations for sculpture in the Abbasid era are the beginning and basis of the decorations of Islamic arts, from which all Islamic decorations were prospered, flourished, and developed.

The complementary relationship between science and art in light of the inventions of Muslim scholars:

With the passage of the historical eras and times in which experimental sciences advanced on the basis of the functional need of man since the prehistoric era up to the Islamic civilization, this knowledge was reflected in the methods and techniques of the subjects of wall paintings, as well as on the architectural surfaces and applied arts, which took a dynamic functional curve, which resulted in a scientific mechanical tricks, which aims to achieve the greatest amount of achievement with less effort using animals, in addition to discovering the forces of nature such as air, water and the sun, and discovering the physical properties of materials.

The topics of drawings and inscriptions generally targeted life and dealt with scenes of agriculture, harvest, industry, medicine, astronomical sciences, etc., and gradually the topics multiplied and departed from the framework of closure on the board of written manuscripts related to different sciences, and were reflected in the design strategy, how to decorate it, the methods of its manufacture, its tools, and how to preserve it against damage factors? The photographic surface became the scene of simulating the mind, conscience, and thoughts of the photographer, so the photographers found their goal in the light of scientific, physical, astronomical, and algorithmic discoveries in various fields.

In light of these multiple variables, the makers of illustrated manuscripts during the Islamic eras faced several issues, the most important of which was how to decorate their applied products in a manner consistent with the values of the Islamic religion while preserving its cultural heritage that is deeply rooted in the collective memory? Likewise, how does he innovate decorative elements that make people feel comfortable and not go back to the pre-Islamic stages? In particular, the tendency of some people who converted to Islam to be proud of their legendary heritage, such as the people of Asia, for example. In fact, the illustrators of manuscripts in Islamic civilization did not clash with the idea of moving away from imitating God’s creation. Rather, it was an opportunity to show the creativity and innovations of the strength and intelligence of the human mind, which derives its strength from belief in the oneness of God, Glory be to Him, the Creator of the universe. Art is in religion, unlike the previous monotheistic religions and philosophical doctrines. This resulted in the creation of visions with perspective dimensions in the pictorial surface without simulating God's creation, and the creation of a general artistic methodology that prevailed in Islamic art styles. Drawings and designs gradually moved from the nature of stagnation to a liberation full of movement, many spirals, oval, central, and other binoculars appeared[10]. It was gradually reflected in the methods of designing elements in Islamic manuscripts, as the makers of Islamic arts used the idea of diversity and repetition of algorithmic functions that gave rise to muqarnas, star dishes, intersecting vaults, and other innovative elements. The relationship between science and art has been a complementary relationship for such an immemorial time, as it is based on utilitarian and functional exchange, where art clarifies the ideas and the steps and functions of the various experimental sciences, and science rises from the objective, intellectual, and technical executive values.

Functions and algorithms from a technical perspective:

Functions of mathematical algorithms relied on the repetition of numbers with different and multiple calculated equations. This mathematical science was reflected in the geometric motifs, so the elements of motifs of stellar dishes and polygonal shapes multiplied, some of which are regular and others irregular in a calculated and accurate manner. The muqarnas decoration, which was designed in a successive and repetitive manner, was numerous and varied, so it seemed as if it was three-dimensional, and decorated with a super smooth flow, as in the intersecting vaults, ceilings, domes, minarets, mihrabs, and capitals of columns. The art that has resulted from algorithmic science can be described as consisting of a subset of generative art (generated by an independent system) and related to systems of art. Therefore, we find that this mathematical knowledge system is reflected in the art of Islamic architecture and its motifs that decorate it with other applied arts. It also cast a shadow over the methods of processing some illustrations of Islamic manuscripts. The system of repetition and reproduction was also followed in some Islamic decorations, its design relied on "one of the basic geometric shapes, such as the triangle, the square, the hexagon, and the octagon, which are multiplied and intertwined in order to extract countless decorative forms from them.[11]"

Arab philosophers such as Ibn Khaldun, Al-Qazwini, and Al-Biruni agreed that the beauty of formation and the achievement of balance that is reflected in the sense of sight is achieved through the proportions of things to each other, as well as their quantities, sizes, conditions, and the ratio of the space surrounding them, and a half, and a like and a half, and a half and a third, and a like and a quarter, and a like and an eighth.[12]" Thus, we can deduce that there is a structural geometric relationship followed by the makers of the muqarnas, which can be classified into two categories, one of which is fixed and based on different types of repetition, whether in color, or design elements and lines, and the other is more complex the farther it is from the center, the more the geometric sequence changes, so it cannot be noticed because it does not follow a geometric element or a self-contained decorative unit. This intellectual methodology was reflected in the design of some manuscripts, especially in the late school stages.

The interrelationship between Islamic mechanical inventions and the structural composition of the elements of forming Islamic images:

The Muslim illustrator believed in the book of God and insight into his creation, and he took science as a means of certainty in the worship of God, and he did not obscure him, or stop him from being prohibited in imitating God's creation, and terminological humanity, as he added to it a mixture of spirituality and emotional coexistence with the hidden worlds that he perceived with his senses and mental imaginations. The history of the prophets and the righteous and the history of kings. The Muslim photographer realized that the surfaces, with their sizes and prominence, possess many dimensions, and this was proven by Muslim scholars through experimental sciences. For example, the muqarnas decoration creates a third dimension, as it connects and meets between the flat and curved surfaces, as it transforms with its graceful geometric elements from the square to the octagon and then to the circle. This rhythmic harmony represents one of the features of the thought of the creative Islamic illustrator, as he was able to break free from the general frozen framework of the art of manuscripts, and the

illustrator became swimming in the space of the manuscript without adhering to any rules. Various artistic schools emerged, the most important characteristic of which is the launch of the movement lines and the elements of the subjects. After the emergence of mechanical inventions, myths and literary themes that extract judgment from the tongue of animals and birds became a reality, as in the manuscript of Kalila Wa Dimna. The painter eloquently expressed his creative imagination and created a virtual reality that combines human attitudes and reality in illustrated manuscripts. This was evident in the schools of Islamic manuscripts such as the Mongolian and Seljuk, which are characterized by intertwined writings, leafing, and elements of living beings, as well as superstitious animals.

The drawings of those manuscripts included Islamic content and values, and perhaps they sensed and called for the importance of reading and knowledge through the use of illustrative images, so their role appeared as an attraction to coexistence in those worlds that deal with their topics, whether from the Qur'an and the noble Prophet's Sunnah, or wisdom, as they constitute a principled image of the virtual conventional world in that historical period, as it does not convey the surrounding reality but expresses it through philosophical and educational visions, as it is like a simulation of the subconscious mind: and the evidence for this is that "Islamic decoration is geometric units or less. They are mathematical units intended for mathematical thinking to reach a truth that is not related to a specific place or time "[13]. It is worth noting that the word (art) is a new word that may be attributed to the orientalists who took the initiative to record the history of the arts of Islamic civilization during the Crusades against Islamic countries. Manuscripts are closely related to experimental sciences, as chemistry related to color powders, inks, paper makers, calligraphers, binders and others contribute to their manufacture.

Schools of Islamic manuscripts in the (Abbasid era):

Islamic art is an extension of the arts of civilizations that preceded it in the geographical areas in which it spread, preserving and integrating with its cultural heritage, as well as adding various styles of Islamic character. It is worth noting that despite the interest in depicting drawings and sculptures on architectural walls and applied arts, they were not associated with the Islamic religion, as they bear the title (Islamic art) associated with civilization. Some scholars attributed that the first annotated manuscript dates back to Khorasan, Iran, in the second half of the 6th century AH / 12th century CE, the era of the Jalayir family under the auspices of the Ghaznavid state, and it is a manuscript from the book Kalila Wa Dimna"[14].

The first schools of Islamic manuscript illustrations were formed at the end of the 6th century AH / 12th century AD, and it is considered the first and oldest school of Islamic painting in the country of Iraq, with its center in Mosul. She specialized in decorating Greek translations of medicine, nature, animals, and plants, then a school was formed in Baghdad in the century (7 AH / 13 AD), then a school in Diyarbakir and Mardin (centers of Bani Artaq rule). These schools were distinguished by having an Arab character rather than an Iranian Seljuk one, with a limited Byzantine flavor. The elements of the designs of illustrated manuscripts in Iraq included geometric shapes such as the square, the rectangle, and the triangle. The subjects also appeared closer to reality, while taking care to modify the drawing of people and taking care of drawing the hero, without observing the anatomical proportions, avoiding anthropomorphism,

and the tendency to flatten and reduce the elements and dispense with shadow and light, surrounding the heads of living creatures with halos, and keeping away from simulating natural color as in reality, in his drawing of plants and nature, and used simplified architectural backgrounds when needed. The elements of the subject were lined up on one or two levels in the foreground of the image, and the decorative elements were dominated by bright colors, which lost the vision of depth with the flatness of the elements. Despite the stagnation that prevailed in the composition elements at the beginning of the stages of the illustrated manuscripts, the spirit of the movement was reflected in the method of treating the decoration of the clothes with lush vegetal units, as well as in some forms of crescents. Some parts of the folds of clothes are composed of textures in the form of worms or intermittent and broken lines. Through these general characteristics, we extract the flow of dynamic movement in the plastic elements of the painted manuscripts.

Fig. 1: The antidote manuscript of Galen, (595 AH / 1199 AD), (The National Library in Paris (No. 2964). Mosul – Iraq)

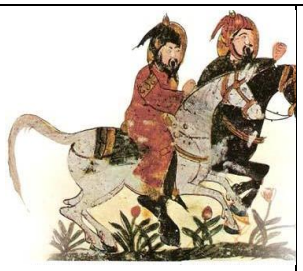


Fig. 2: The Book of Veterinarians, (606 AH / 1210 AD) (The authority of the Topkapi Saray Museum, Turkey)

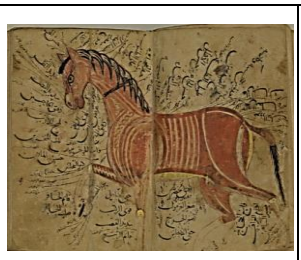
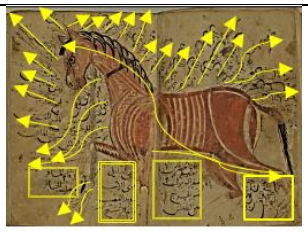
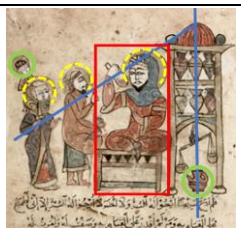


Fig. 3: The Book of Veterinary Medicine, (605 AH / 1209 AD), (The Egyptian Book House (under No. 8), Dr. Khalil Agha)

Fig. 4: Kalila wa Dimna, 747 AH / 1346 AD, from the King Faisal Center for Research and Islamic Studies





Geometric Design	Line movement		Repetition and symmetry	Panel surface division	Flat perspectives	The space in the background	Concentration and agglomeration of drawing elements	For ground line	Colors	Mechanical Shapes	The movement	The contrast of shadow and light	architectural background	Manuscript content frame
	Soft	Sharp												
4	3	3	3	4	0	3	3	1	3	3	3	0	1	0

Scale; 0 None - 1 few - 2 there - 3 proportional - 4 spread - 5 is dominant at work

In the era of the Abbasid Caliphate, scholars received great attention, and jurists competed for knowledge and disseminated it among people. Schools, libraries, and their accessories were

established, and scholars were attracted from all over the world, without standing on their ethnic origins or beliefs. different community service. The Arabic manuscripts presented comprehensive studies of the scientific heritage of previous ancient civilizations and re-established their methodology, expanded, added, and reformed theories with the help of illustrations, and the social sciences shared this interest.

Muslims realized the importance of calculating the circumference of the globe, latitude, and longitude, and dimensions of distances and areas that would help them plan cities and agricultural land areas, so the Abbasid caliphs took care of agriculture and irrigation methods and built dams, bridges and water channels to transport water, and they took care of and developed farming tools, and they delivered water to homes and palaces through the idea of Hammered pots. It is worth noting that Muslim geographers and astronomers were able to draw geographical maps corrected from Ptolemy's maps. The caliph al-Ma'mun (215 AH/830 CE) commissioned a group of scientists to measure the length of the earth to extract the unit of distance measurement for arithmetic and astronomical transactions. Examples of these scholars are the Persian scientist Jacob bin Tariq in the century (2 AH / 8 AD) during the reign of the caliph Abu Jaafar al-Mansur, who made him meet the holder of the book (Siddhanta). (Siddhanta) known as Mr. Kankah or Mankah in the year (149 AH/767 AD). Likewise, the astronomer and mathematician Sanad bin Ali, known as Abu al-Tabib, during the century (3 AH / 9 AD) during the reign of the Abbasid caliph Abu al-Abbas Abdullah bin Harun al-Rashid and other scholars who collaborated together. The Arabs cared about studying plants and crops, their seasons of cultivation and harvesting, and how to store them? Plant science is related to the sciences of medicine, pharmacy, perfumery, and dye extraction. Many Muslim scholars devoted books to the study of botany and plantations, such as: Abu Zakariya Yahya bin Muhammad Ahmed bin Al-Awam Al-Ishbili Al-Andalusi during the 6th century AH / 12 AD) the author of the book of farming, and Dawood bin Omar al-Antaky during the century (11 AH / 16 AD), and Abd al-Latif bin Yusuf bin Muhammad Ali bin Abi Saad during the century (6 AH / 12 AD) who was a contemporary of the rule of Salah al-Din al-Ayyubi, and Abu Abdullah Zakariya bin Muhammad bin Mahmoud Al-Qazwini during the century (7 AH / 13 AD), who was a contemporary of the last caliph of the Abbasids in Baghdad, the caliph Abu Abd al-Majid (Al-Mustasim Billah) Abdullah bin Mansour Al-Mustansir Billah, and Abu Abdullah bin Muhammad Al-Idrisi Al-Hashemi (493-559 AH / 1100-1166 AD) the owner of the oldest map, the scientist who moved to live in Sicily during the reign of King Roger II after the fall of the Islamic caliphate in Baghdad, and Abu Hanifa al-Dinuri, relative to the town of al-Dinur in Iran during the century (3 AH / 9 AD), who excelled in the study of astronomy and plants and their hybridization, as he added to the Greek scientist (Ziaskoridos) in the field of medicinal plants and other Muslim scholars[15]. These scientists invented different tools to help them in their discoveries, such as astrolabes, compasses, and reflective devices for images of stars and planets and others. These inventions were contemporary with the makers and illustrators of manuscripts, and this was reflected in their pictorial themes, so they decorated scientific books in the Middle Ages. Among them were drawings of the antidote manuscript (Fig. 1) by Galen, a copy of Muhammad bin Ahmed, which contained many manifestations of environmental life. Despite the illustrator’s division of design into three sections, it beats movement and dynamism.

The upper level is devoted to Kufic writing decorated with delicate plant branches and curves, and the middle level includes the farmer on the far left (Andromache) who supervises the farmer in a calm manner. A variety of harvesting and planting is represented by those who study wheat (in Norway), animals that help people in harvesting wheat in the orbit, a woman who sifts wheat, and an animal that carries plants. We note that the drawn elements have become part and parcel of the manuscript's design. The photographer used some flexible spiral binoculars in a position approaching symmetry and equilibrium, which suggests flexibility and coherence in design.

Muslim scholars realized the environmental balance that God created, and among them were animals. Abu Ali ibn Sina (370-427 AH / 980-1037 AD) was concerned with studying the types of animals in his book Al-Shifa for the Study of Animals (6 AH / 12 AD), and Dawood bin Omar al-Antaky century (10 AH / 16 AD) with an accurate description of animals and birds, and Abu Yahya Zakariya al-Qazwini at the beginning of the century (7 AH / 13 AD) in his book "Wonders of Creatures", and Abu Al-Hassan Ali bin Ismail, nicknamed Ibn Sayeda (5 AH / 11 AD) In his book chapters on everything related to horses, Abu Othman Amr bin Bahr bin Mahboob bin Fazarekh Al-Laithi Al-Kinani, known as Al-Jahiz (3 AH / 9 AD), wrote many books on the types of animals. These extensive anatomical studies contributed to studying animal behavior, preserving and improving their breed, and discovering medical drugs to treat and benefit from them. Experimental Muslim scholars used the muscular efforts of some domestic animals. Some of them operated water cranes with them, and some of them took their forms as aesthetic and decorative elements in their mechanical inventions, such as the sons of Musa bin Shaker Muhammad, Ahmed, and Al-Hassan (3 AH / 9 AD). Which contains nearly a hundred mechanical inventions, including animal forms that emit artificial sounds after being quenched with water through containers and buoys filled with water and plugs to empty the water.

Al-Musawwar continued to adhere to the general characteristics of the art of manuscripts of the Arab school in Baghdad, which are the lack of surrounding the drawn elements with a frame, the appearance of space in the backgrounds, loose clothing, grinding, and Persian features, as in the book Al-Baytara (Fig.2). The beginning of the drawings was manifested in a way full of movement, represented by the movement of horses, and departed from the framework of stagnation that was prevalent and followed in the style of the Arab school in Baghdad (606AH/1210AD). The painter showed some balanced depth, so he made one precede the other, showing the beauty of the graceful movement of the horse's tail on the one hand, and on the other hand, he showed the movement of the extension of the two horses' heads through color contrast. We note that at that stage, the general features of that school prevailed, which is the stacking of shapes on one line, which represents the floor of the elements that contain some plants. The background was also devoid of any elements, and although the painter maintained the general adherence that prevailed in the schools of photography at the time, the elements appeared to be moving and liberated from a framework that confined them. It seems that it was not limited to an attempt to animate the human and animal elements only, but also included the calligraphy element, which is one of the basics of the beginning of the manuscripts. We find in (Fig. 3) the book of horses and veterinarians by its author Abu Yusuf bin Aky Hazam (3 AH / 9 AD), the trainer of the horses of the Abbasid caliph al-Mu'tadid. The painter revealed a hidden

power in the directions of the illustrations scattered in a semi-random and irregular radial manner, as in the past era of the organization and formation of Arabic calligraphy. To discover the third dimension in the design of manuscript graphics.

The interest in the drawings of illustrated manuscripts paralleled the drawing of scenes of medicine, anatomy, and philosophical and political literature with the aim of societal reformation, as the copies of the Kalila and Dimna manuscripts (597-617 AH / 1200-1220 AD / 618-628 AH / 1220-1230 AD / 755 AH / 1354 AD) contained two groups of topics, Part contains humane scenes that take place between King Khosrow Anushirwan and the Persian doctor Brouzia, and the other part is literary stories that are conducted on the tongues of animals, all of which call for wisdom and learning from situations. The painter formed a virtual environment to simulate social situations and use Indian stories that were re-addressed to employ them to present the problems of the era and the participation of the ruling class and the ruled. The elements of the Persian physician's treatment manuscript appeared in Bruzieh for the general public (Fig. 4) on one plot line, and the doctor was drawn in a larger size holding the drugs in a position facing the patients, who appeared in a smaller, gradual size. Symmetry appeared in the triple numerical frequency in the number of subjects, as well as in the number of adjacent vials located behind the physician. Between the sharpness of the straight lines and the formation of rectangular masses, the monotony of the rhythm was broken by the mutual curves of the halos surrounding the heads of the persons, the dome, and the semicircular arc, as well as in the curves of the shapes of the flasks intended for storing medicines. The painter maintained the design balance on both sides of the manuscript through the oblique juxtaposition of the jar, which is located at the bottom of the wooden wheel, and between the head of a person, which suggested the innate perspective depth.

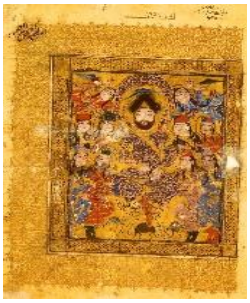


Fig. 5: The Book of Songs (614 AH / 1271 AD)

Fig. 6: Maqamat al-Hariri (622-632 AH) (Bibliotheque Nationale de France)

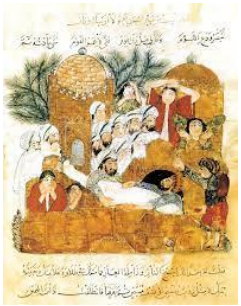
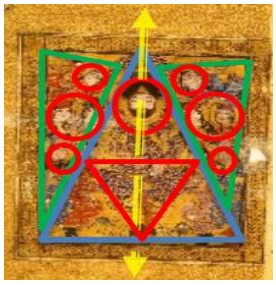
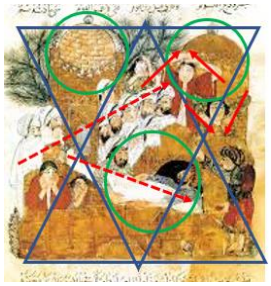
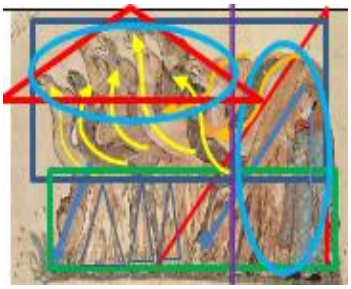


Fig. 7: Maqamat al-Hariri (622-632 AH) (Bibliotheque Nationale de France)

Fig. 8: Maqamat al-Hariri (634 AH / 1237 AD) (Bibliotheque Nationale de France)







Geometric Design	Line movement		Repetition and symmetry	Panel surface division	Flat perspectives	The space in the background	Concentration and agglomeration of drawing elements	For ground line	Colors	Mechanical Shapes	The movement	The contrast of shadow and light	architectural background	Manuscript content frame
	Soft	Sharp												
5	4	4	4	4	3	3	4	3	4	3	4	2	3	2

Scale; 0 None - 1 few - 2 there - 3 proportional - 4 spread - 5 is dominant at work

The scientific movement continued between studying and deepening the universe and creating functional tools, and between mechanical inventions that pleased souls and sent a spirit of reassurance. Prince Badr al-Din Lulu' al-Atabaki appears in (Fig. 5), who is owned by Armenia until he became a sultan of Mosul, he is dressed in blue silk clothes, and it appears that the prince is sitting with a bow in his hand as a symbol of authority among the Turks, and eight people surround him and sitting on his sides, and they all appear to have Turkish skin tone. At the top of his head, there are two angels holding an umbrella that surrounds his head, and on his arms, there are two ribbons with his name written on them. We notice the central composition, the balanced symmetry, and the numerical repetition of the figures on both sides of the prince, while the general structure is hierarchical, the top of which is the head of the prince, which seemed larger than the rest of the figures. This treatment may be similar to the Byzantine halo that distinguishes people of high status.

Yahya bin Mahmoud al-Hariri (446-514 AH / 1054-1121 AD) is considered the first scholar of literature editing, as he authored the first Maqamat Arafa under the name of the Hariri Maqama. Sharif al-Din Abi al-Nasr Anushirwan bin Khalid bin Muhammad al-Kashani, the minister of the Caliph al-Mustasharid Allah, admired it, and its approach was Al Hariri. Fifty articles were narrated by an imaginary person with intelligence and knowledge about events, experiences, and extensive information, which gave the work a spirit of riddles, jokes, humor, and sanity[16]. One of the images of these shrines included the manuscript of Maqamat al-Hariri (Fig. 6), which depicted a scene for one of the councils of knowledge in the Abbasid era, where the elements of the composition were formed in a hierarchical shape, showing in the background the library of books with square repetitions, and located below it in the foreground block, a group of men turning their eyes and bodies towards the jurist teacher who holds a book. Both sides of the lines of the design were surrounded by slanted and repeated semi-contracts towards the interior, which attracts the eye to the centrality of the subject. It seems that the design is based on a rectangular geometric shape, as it was divided into two parts. The lower half contains human elements, while the upper half contains places for keeping books. The painter achieved unity between the elements of the formation by being able to repeat the squares of the shelves of the bookcase and the explicit geometric lines, as well as the diversity in the curves and masses of the bodies. The manuscript carries a symbolic meaning that is interrelated. The base of science and science is represented in books. Its roots come from the maturity and learning of human minds. It is worth noting that the photographer did not neglect to show one of the decorations

of the friezes of architecture, which witnessed a renaissance and development in this era due to the progress of experimental sciences.

The art of manuscripts developed gradually until it reached maturity, as the manuscripts of the Maqamat Al-Hariri book, on the tongue of Al-Harith bin Hammam, dealt with the adventures of Abu Zaid Al-Sarouji, and it was copied by Yahya bin Mahmoud Al-Wasiti. One of the two versions dates back to (634 AH/ 1237 AD) and is kept at the Bibliothèque national de Paris, known as (Maqamat Shafer). This manuscript included accurate and varied scenes from realistic daily life, and the sublime Arab features appeared, as well as the diversity of personalities and different features, and the halos that surrounded the heads disappeared. The themes of Maqamat al-Hariri (Figure 7) represent at this stage a major development in the path of distributing patterns of human gatherings combined with architectural and botanical backgrounds at varying levels. We note the way its elements are distributed in a deep spiral manner, in its center is the subject of the maqam, which is the state of burial, which inspired the third dimension[17]. Harmony and consistency harmony of the performance of the design, balance, and cohesion of the units of the elements were achieved by following the strategy of exchanging the repetition of the opposing triple performance, where the formation appeared in an ascending hierarchical form at the top of one of the groans located in the middle of the manuscript between the two domes of the tombs, and the rocks of the mountain represented the base of the pyramid. While the inverted pyramidal shape was repeated, its base became the domes of the tombs, and its top was the mountain rocks. The contrast of the reciprocal directions between up and down through the contrast of raising the arms of the mourners, and between the tendency to lower the body of the deceased to the bottom and the upward gradation of the depositors of the deceased's family. Al-Musawwar succeeded in fully philosophically expressing the death sermon in the Islamic religion, as mentioned in the noble Quranic verse." Everyone upon it [i.e., the earth] will perish [26], And there will remain the Face of your Lord, Owner of Majesty and Honor [27], So which of the favors of your Lord would you deny [28]; Ar-Rahmān"[18]. Although the theme of the shrine is dominated by sadness and gloom, the dynamism of the design and the bright, luminous colors reflected the spirit of renewed hope.

Al-Wasiti dealt with the issue of the ten camels (Fig. 8) from the rural environment. The surface of the design was divided into three distinct and intertwined rectangular blocks interspersed with two triangles, the largest of which occupies the upper part and is located in the foreground, containing the movement of raising the necks of the cannons in a repetitive manner, as if emphasizing the feature that distinguishes the camels from the height of the length of the neck and feet. Drawing two camels stepping down to eat grass, as well as the variety of blocks, directions, and curves of lines. The woman who stands at the far right of the manuscript is the point of stability and balance starting and repeating the escalation of the curves of the necks of the fountains, as well as the line of stability of the earth on which all the elements stand.

The Arab school in the era of the Mongol Ilkhanate:

Astronomy is the opening of the sciences of mathematics, engineering, algebra, and mechanics. Thanks to the interest in these sciences, the translation movement started the era of the Caliph al-Ma'mun. Despite the attacks of the Turks and Mongols from northern Asia on the east and

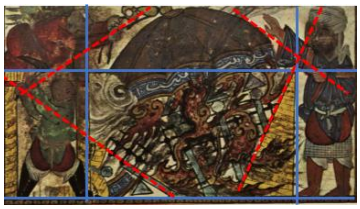
west, they contributed to the revival and recovery of the scientific schools of Arab Muslim scholars. Bin Ahmed Al-Biruni to India, who was a disciple at the Baghdadi school. Al-Biruni was able to familiarize himself with Indian myths and traditional stories, and the establishment of the Seljuk Sultan Jalal al-Din Malkshah (464-485AH/1072-1092AD) the calculation calendar and the Persian calendar in the style of the Baghdadi school, and the Mongol Sultan Hulagu (656 AH) established (1259 AD) a monitoring box in Maragheh for the astronomer, the mathematician Nasir al-Din al-Tusi, and a group of scholars such as Muayyid al-Din al-Dimashqi and al-Qazwini who brought books from Khorasan, the Levant, Mosul, and Baghdad, as well as scholars, writers, and skilled craftsmen in his court in Samarkand, as Sultan Kublai, Hulagu's brother, was keen to transmit sciences and arts from Baghdad and Cairo to China, during the reign of Sultan Koshio King (678 AH/1280AD), then Muslim sciences and innovations continued to attract the attention of sultans and kings who were keen on the renaissance of their homelands. We find the Mameluke Sultan Muhammad Al-Nasir Ibn Qalawun (630-670AH/1310-1341AD) keen to expand the establishment of schools and books, he was interested in crafts and various trades, and the revival of useful sciences and their theories to encourage people to receive knowledge, so sciences and arts flourished at that time. The rulers realized the basics of the establishment of civilizations and states, so they inherited the adoption of scholars and expanded the establishment of books. The style of the Arab school continued despite the fall of the state of Khwarazm Shah (614 AH/1218 CE) in Iran, the weakness of the Abbasid Caliphate (656AH/1258CE) in Baghdad at the hands of the Tatars, and the concurrent rule of the Mamelukes in both Egypt and the Levant. Genghis Khan succeeded Haulage, who established the Ilkhanid dynasty in Iran, after which it was divided into states ruled by families (Al Muzaffar family, Jalayir family, and others). He recognized the Islamic religion as an official religion by embracing (Gazan Khan), nicknamed (Mahmoud Khan) (694-703AH/ 1295-1304AD). Chinese influence appeared clearly alongside the style of the Arab school in Tabriz. The photographer in the Arab school relied on building repetitive geometric formations alongside some of the binoculars he invented, so the formations appeared decorative. However, during the Mongolian period, he highlighted the depth and the third dimension, simulating reality. The lines of the earth multiplied with the opening of the horizon that represents the sky (chi) without specifying lines. The middle space has become single in the scene of events that consist of people and animals of large sizes that are almost larger than the buildings. Most of the subjects were dominated by the tinge of tragedy and conflict due to a large number of wars.

Fig. 9: The Book of Benefits of Al-Hayoon by Ibn Bakhtishu', Lion and Lioness (736 AH / 1336 AD) (The Pierpont Morgan Library &Museum New York)

Fig. 10: Book of Athar al-Baqiyya on the Unearthly Centuries, Al-Biruni, Destruction of the temple of Jerusalem, (707 AH / 1307 AD) (Folio158 verso, University Library, Edinburgh)

Fig. 11: Rashid al-Din's manuscript from the book Jami' al-Tawarikh (656 AH / 1258 CE) (the library of the Topkapı Palace in Istanbul)

Fig. 12: Alexander kills the rhinoceros. The Shahnameh manuscript by Ferdowsi (Demot) (720 AH / 1320 AD) (Museum of Fine Arts, Boston, MA)



Geometric Design	Line movement		Repetition and symmetry	Panel surface division	Flat perspectives	The space in the background	Concentration and agglomeration of drawing elements	For ground line	Colors	Mechanical Shapes	The movement	The contrast of shadow and light	architectural background	Manuscript content frame
	Soft	Sharp												
5	5	5	5	5	1	1	5	5	5	4	5	4	5	2

Scale; 0 None - 1 few - 2 there -3 proportional - 4 spread - 5 is dominant at work

Most copies of the colored manuscripts were made in the Mongol era, the Ilakhani in Iran (656 AH / 1258 AD), and continued in the middle of the century (8 AH, 14 AD). And the most famous illustrated copy is the manuscript of Ibn Bakhtishu's Book of Benefits (Fig. 9), which was copied in Maragheh during the reign of Sultan Ghazan Khan (697 AH / 1298 AD). The researchers divided it into two parts: the first includes pictures in the style of an Arab school in Iran, and the second includes pictures drawn in the style of a Mongolian school. The design formed a pyramidal design located in the middle on the base of a simple landline sandwiched between two different types of plants. The constructive movement escalated between the turning and meeting of the two animals smoothly. The triple symmetrical harmony continued in the repeated circular blocks that contain the heads of the lioness and the lion and one of her

hind legs. The triple rhythm was repeated in a balanced way through the harmony and different directions of the wrapping and swaying of the branches of plants and the decorative treatment of the lioness's hair. The painter followed the method of repetition of the reciprocal blocks of triangles, which gave an illusion of dynamic movement between soft lines and sharp lines, and the balanced design structure of the two animals. The style of the Arab school in Iran continued in the book Al-Athar Al-Baqiyya on the Empty Centuries of Al-Biruni (Fig. 10), which was copied by Ibn Al-Qutbi (707AH/1307 AD). It depicted a tragic scene that almost expresses the moment of the event of the destruction of the temple in Jerusalem. It contains the mass of the dome of the sanctuary, which collapses on the ruins of the broken columns. On the right side of the manuscript, a large man appears about the height of the temple, which is one of the features of the art of the Mongol Ilkhanate era, while the left side shows two figures working to demolish the temple. The mass of the dome had the largest central area of the manuscript and appeared in a compound accumulative position. The gestures and directions of the men's hands heading towards the dome helped to attract the eye to the centrality of the manuscript, which gave an illusion of the movement of turning the diagonals of the spiral surface perspective, in addition to the use of dark colors that created weight, and scattered and distributed smooth movement through the scattering of columns.

The greatness of the personality of the Sultan that the Mongolian Ghazan Khan is in the book (Jami' al-Tawarikh or the History of Ghazani) at the hands of the Mongolian minister and physician Rashid al-Din, who immortalized the history of the Turkish and Mongolian tribes and the history of the Genghis Khan dynasty until Ghazan Khan, and the second part was completed in the era of Muhammad Khodabandeh Olgaito, the eighth king of the Ilkhanate (7th AH /13th AD) related to the beginning of the history of the world, the prophets, religions, beliefs, and the history of the Persians, as well as the history of Islam and the end of the weakness of the Abbasid state. The mechanical inventions known as the science of tricks continued in the manufacture of military weapons. They developed ships, catapults, and fire launchers, and they invented wooden boxes that resemble tanks and excelled in using them. They also invented various methods in military buildings, including bridges, fortified doors, castles, and others. Rashid al-Din's manuscript from the book Jami' al-Tawarikh (Fig. 11) shows a scene of the Mongols' siege of Baghdad before its storming. The elements were distributed on several successive levels, without taking into account the anatomical proportions and perspectives. In the foreground appeared the large arch that symbolizes the gate of the palace and its storming, while showing the intruders in a large size. The elements of the architecture merged with the decorative wormhole flow of the Tigris River, which is the style followed by the Arab school in decoration. The treatment of architectural forms has evolved from what it was in the era of the Ilkhani, so it was drawn accurately and flowery motifs were employed on it, which reflected the architectural development in that era, and it is one of the fields related to experimental sciences. The painter showed the intensification of the battle between the two sides in a contrasting and balanced way, by flying and aiming weapons. He followed the symmetrical triple-repetitive rhythm in the successive ships, while the reciprocal triple rhythm was used in the masses of the conflicting armies. He also distributed the firing machines that resemble cannons in separate semi-parallel places, which created a connection between the elements, adding the spirit of

realism and dynamism to the manuscript. The painter dealt with his subject in a philosophical way, in which there is a message of hope while showing the valor of defending Baghdad despite the scenes of fighting, war, and conflict through the use of bright colors and not showing scenes of violence and bloody tragedies.

In one of the manuscripts of the Shahnameh of Ferdowsi known as Dimot, which is attributed to its last owner (Fig. 12), Alexander kills the rhinoceros. Opinions differed about determining the date of the year to which it is attributed, between 720 to 745 AH / 1320 AD to 1345 AD, and some of its illustrations are attributed to the painter Shams Al-Din, the era of Sultan Al-Jalairi, Sheikh Al-Din Uwais (757-776 AH /1356-1374 AD). This manuscript bears the characteristics of the Mongolian school in Iran, where the surface of the manuscript was divided into several levels through the front and back mass. It was dominated by Chinese influences in terms of features, treatment of botanical nature, and mythical forms. It shows a group of soldiers following their leader, Alexander the Great, who wears a crown and confronts the brutality of the mythical rhinoceros, which appeared as a winged animal with a long-pointed horn. The development of the style of the Arabic school in the era of Al Jalayir, where the development of interest in showing the strength of the line appeared in its movement and in its divisions of surfaces, as well as it appeared in the form of writing strips in the Kufic script. The strength of the line was represented in the design of the blocks and the variety in their swaying. On the right side of the manuscript, we notice the sequence of frequency of the brackets of the blocks that correspond to the sequence and frequency of the soft lines on the left side. We also notice the use of the spiral perspective, whose kinetic energy emanates from the axis and hero of the subject, which is Alexander the Great. The strings of the spiral perspective move and expand outwards through the flowing soft lines represented by trees, and the bending of the rhino under the rush of Alexander's horses and soldiers, which gave the impression of the interdependence and cohesion of the elements. He emphasized showing the person and status of Alexander through the tight color contrast on both sides of the illustrated manuscript, where the hero appeared in light colors. This pictorial phase is a development of the objective and pictorial treatments of the Arab school in the era of Al Jalayir, as it was characterized by the dynamism of movement and its hesitation with the diversity in the use of lines and motifs and the treatment of nature with a unique artistic vision, despite the clear Chinese influences, but it took on its own character.

The Arab School in Syria and Egypt:

Political conditions contributed to the renaissance of the art of making Arabic manuscripts in both Egypt and the Levant, where the Tatars invaded Iraq and the city of Baghdad fell, then there were successive migrations of scholars, craftsmen, merchants, and art moans to Egypt, which contributed to preserving the core Arab character. Despite the scarcity of finding manuscripts of the Tulunid and Fatimid eras, the Mameluke era in Egypt and Syria contained the distinctive character of the features of the Arab artistic schools that arose in the Abbasid era, in addition to them, and developed their status. The Seljuk styles followed in the Atabeg era continued under the rule of the Ayyub state, as the styles of the Arab school in Iraq mixed with some Byzantine and Seljuk influences. Libraries have spread throughout the Islamic world,

as Baghdad alone contained 36 libraries in the Abbasid era, and its mission was authoring and translation. The most famous of these libraries is the House of Wisdom library, which was built by Al-Rashid in (169 AH / 786 AD) and contained nearly a million books during the reign of the Caliph Al-Ma'mun. This was reflected in the diligence of Arab scientists who are authorized to study mathematical and experimental sciences in laying down basic rules for mechanical and physical sciences, realizing the importance of accomplishing arduous tasks with little effort. Al-Zaman Al-Jazari[19] is the founder of the science of algorithms, and he is called the father of mechanical sciences. In the modern era, he is one of the foundations of the science of moving robots, and he is the author of the book (Al-Jami' between knowledge and useful work in the manufacture of tricks) during the reign of Sultan Nur al-Din Muhammad bin Kara Arslan from the Banu al-Artaq, who commanded him in the year (579 AH / 1181 AD) to write his scientific and practical inventions in the city of Diyarbakir or Amed[20]. Al-Jizari completed the book in the year (602 AH / 1206 AD) during the reign of the good Sultan Nasir al-Din Mahmud (Mahmud II), the last emir of the Zangid rule of Mosul (1219-1234 AD) during the reign of the Caliph Nur al-Din Arslan Shah II. The book contains a detailed explanation of many mechanical and hydraulic structures for different types of machines such as clocks, observatories, and water levers, as well as entertainment utensils for kings and caliphs, such as a statue pouring ablution water, and another for pouring greedy drinks with different tastes. It is worth noting that Al-Jaziri is one of the episodes of the Crucible of Arab Scientists and Engineers series, and the mathematicians who preceded them in the civilizations that preceded Islam, and the traces of their inventions and discoveries are still the basis of contemporary engineering and mechanical sciences, evident to this day.

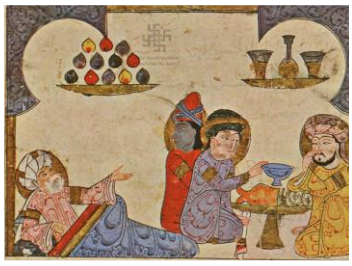


Fig. 13: Manuscript of the letters of the call Doctors, Ibn Batlan that Al-Baghdadi (672 AH / 1273 AD) (Islamic Museum Egypt)

Fig. 14: Al-Jaziri, The Elephant Hour, (715 AH / 1315 AD) (Eight folios from this manuscript in the Freer and Sackler Galleries, Smithsonian Institution).

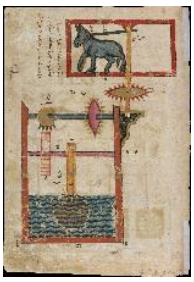
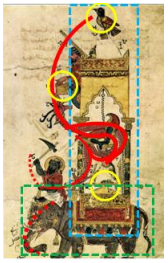
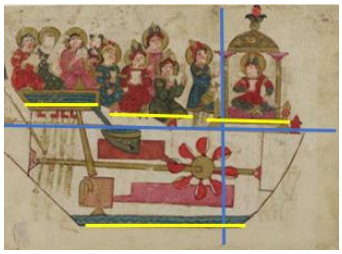


Fig. 15: Al-Jaziri, Water Wheel, (715 AH / 1315 AD)

Fig. 16: Al-Jaziri, a robotic musical toy

Geometric Design	Line movement		Repetition and symmetry	Panel surface division	Flat perspectives	The space in the background	Concentration and agglomeration of drawing elements	For ground line	Colors	Mechanical Shapes	The movement	The contrast of shadow and light	architectural background	Manuscript content frame
	Soft	Sharp												
5	4	4	3	4	3	3	5	3	5	5	5	3	4	3

Scale; 0 None -1 few -2 there - 3 proportional - 4 spread - 5 is dominant at work

The style of the Arabic school continued in Syria, as it sought the help of painters who emigrated from Baghdad as a result of the Mongol invasion. Among the examples of these manuscripts is the manuscript about “Inviting Doctors to a Feast” (Fig. 13), by Ibn Batlan Al-Baghdadi (672 AH / 1273 AD), which most likely dates back to the Mameluke era[21]. Imagine the scene of one of the doctors lying down and in front of him, a group of men gathered around the dining table. The painter divided the area of the design by two-thirds, and he confined its elements within geometric shapes between squares, triangles, and circles. He surrounded the elements with an architectural arch with opposite arcs, in the form of a horseshoe. The painter combined the logical movement of the gestures of the heads and hands, and the illogicality of the utensils with flying Mameluke features in a fixed position at the top of the manuscript, which suggested breaking the sharpness of the symmetrical repetition. It is worth noting that the style of the Arabic school continued until the end of the Mameluke era when Ibn Al-Razzaz copied an ornate copy of the original copy of the book (Al-Hayyal Al-Jami’i between Knowledge and Action) during the reign of the Artuqi Sultan Noor al-Din Muhammad bin Qara Arslan in Diyarbakir[22]. The manuscript included precise and clear explanations for all parts and structures of the mechanical and hydraulic inventions of the machines that operate on their own. Scientific character in the century (6AH/12AD). Al-Jaziri explained the structure and mechanics of his invention, such as the elephant clock (Fig. 14), as it is an extension and alternative to the hourglass invented by the ancient Egyptians. The manuscript was painted with watercolors and lint and gilding were used on paper. We note the kinetic harmony in the vertical mechanical structure consisting of interconnected animal parts. The book (Knowledge of Engineering Life) by Al-Jaziri also contained an illustration of a water wheel driven by a donkey (Fig. 15). In the section on devices for raising water from ponds or wells, it explains how to use some animals such as a donkey that moves around the column with the lever arm attached to its neck. Its movement leads to the rotation of the wheels, thus lifting the large ladle out of the water at regular intervals, and then how the water is discharged into the irrigation canal. Al-Jaziri is the

first founder of software science, employing hydro-hydraulic power. His invention was (Fig. 16) a blue boat in which four artificial musicians played songs and entertained the audience in royal ceremonies, and the machines were hydraulically programmed with the help of water propulsion. The basis of the science of moving gears and mass interdependence was based on a balanced sequence to perform the tasks, as the parts push each other with calculated accuracy to generate the required force according to the nature of the task. Just as the algorithms reached to solve the most difficult problems, the manuscript illustrator was also able to present his topics in a form commensurate with Islamic jurisprudence, expressing his topics, which were reductively realistic, and full of dynamism.

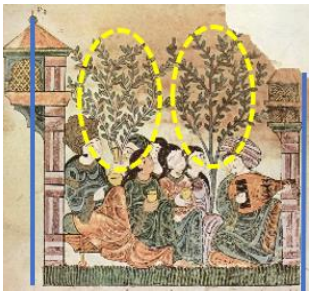
The Arab School in Morocco and Andalusia:

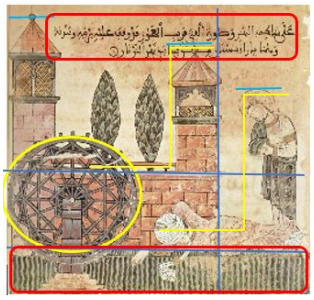
The traditions of the Arabic school style continued in Iraq and spread in Egypt and the Levant. It also moved to North Africa and southern Europe, where Spain, "The caliph al-Hakam sent envoys to the East to buy manuscripts and established a complex for the art of the book, in which he gathered calligraphers, illustrators, and ideologues, to copy the manuscripts, decorate them with pictures, and take them away "[23]. It is worth noting that this stage was paved by the rule of the Idrisid who sowed the seeds of scientific knowledge in Fez and spread it in the Far Maghreb (187 AH/803AD), following the example of the scientific movement led by the Abbasid state in the Islamic East. The geographical location of the Moroccan city of Fez and the countries of Andalusia helped in the development and progress of the movement of sciences through commercial activity across the Mediterranean, and with the dominance of the Aghlabid rule and the elimination of the Idrisid rule, the curricula of Islamic sciences were transferred with them in various fields, following Islamic principles, and the arts of Islamic architecture spread and methods of a special nature were developed. He was known for the Moroccan, Andalusian, and other styles, and this was reflected in the diligence and ingenuity of the craftsmen in various fields, especially with the expansion of the Aghlabids in France, Italy, and Greece, and their introduction of new industries in the West based on crops imported from the Levant, such as cotton, where textiles are made, and sugar cane from Africa, where sweets are made. Likewise, industries based on mining, such as iron, copper, and silver, and silkworm breeding for the silk industry, whose industry spread in Sicily in the 6th century AH / 12th century AD. Then the Zirid state followed them, which did not preserve the glories of the Aghlabids, so their rule was limited to Tunisia, Algeria, and the city of Bejaia. Despite their extravagant interest in the architecture of their palaces, they did not succeed politically and militarily. Abd al-Rahman the first who the Umayyad nicknamed the Just (Al-Adel), who was able to push the country of Andalusia since the year (137AH -178 AH /755 AD -795 AD) towards progress and sophistication on the religious, scientific, literary, and philosophical levels, which encouraged the wheel of innovation and scientific experimentation out of love for science and following the example of Islamic law, which commands the building of the land and the preservation of the environment and life out of respect for humanity, so he cared about agriculture, industry, arts, and architecture, and his son Abd al-Rahman II, the era of the Abbasid caliph, followed him, and he was followed by several caliphs, the most prominent of whom was Abd al-Rahman III (315 AH / 912 AD), who was able to maintain security in the

country, and he cared about agriculture and encouraged scholars and industrialists to advance sciences and arts. Cordoba and Al-Zahraa were adorned with buildings of unparalleled sophistication, and people competed to acquire science and innovation under the shadow of the Umayyad caliph Abd al-Rahman II ibn Abd al-Rahman al-Dakhil (206 AH / 822 CE). Who preceded him and composed the notes of the musical scale, and after him nearly seventy years, Al-Farabi developed the Al-Rababa instrument, then Bin Zaryab added a fifth string to the Oud after it was four strings, as he "established in Cordoba a school and he installed a fifth string to the lute after it was four, and they practiced poetry, especially the system of stories that included interesting jokes, so many men and some women excelled in it, and they learned in schools the sciences of astronomy, geography, logic, medicine, grammar, geometry, algebra, the principles of natural science, medical chemistry and natural history, which is the science of births "The Three Floors" (Louis Seydou: 2018)[24]" . These sciences were employed to innovate machines, and engines for industry, agriculture, textiles, music, construction equipment, drawing tools, wood carving, metal shrouding, weapons industry, etc., and the effects of that activity were reflected in the elements of forming illustrated manuscript units that showed the surrounding environment, the diversity of textiles, crops, buildings, and various activities between war and peace. Work, struggle, preaching, wisdom, death, life, clarification, and explanation of successive innovations and inventions.

Fig. 17: Hadith of Riyadh and Bayed, (8AH /14 AD)
Vatican Library, cataloged as Codex Vat.

Fig. 18: Hadith of Riyadh and Bayed, (8AH/14AD) Vatican Library, cataloged as Codex Vat.





Geometric Design	Line movement		Repetition and symmetry	Panel surface division	Flat perspectives	The space in the background	Concentration and agglomeration of drawing elements	For ground line	Colors	Mechanical Shapes	The movement	The contrast of shadow and light	architectural background	Manuscript content frame
	Soft	Sharp												
5	4	4	3	4	3	3	5	3	5	5	5	1	4	0

Scale; 0 None - 1 few - 2 there - 3 proportional - 4 spread - 5 is dominant at work

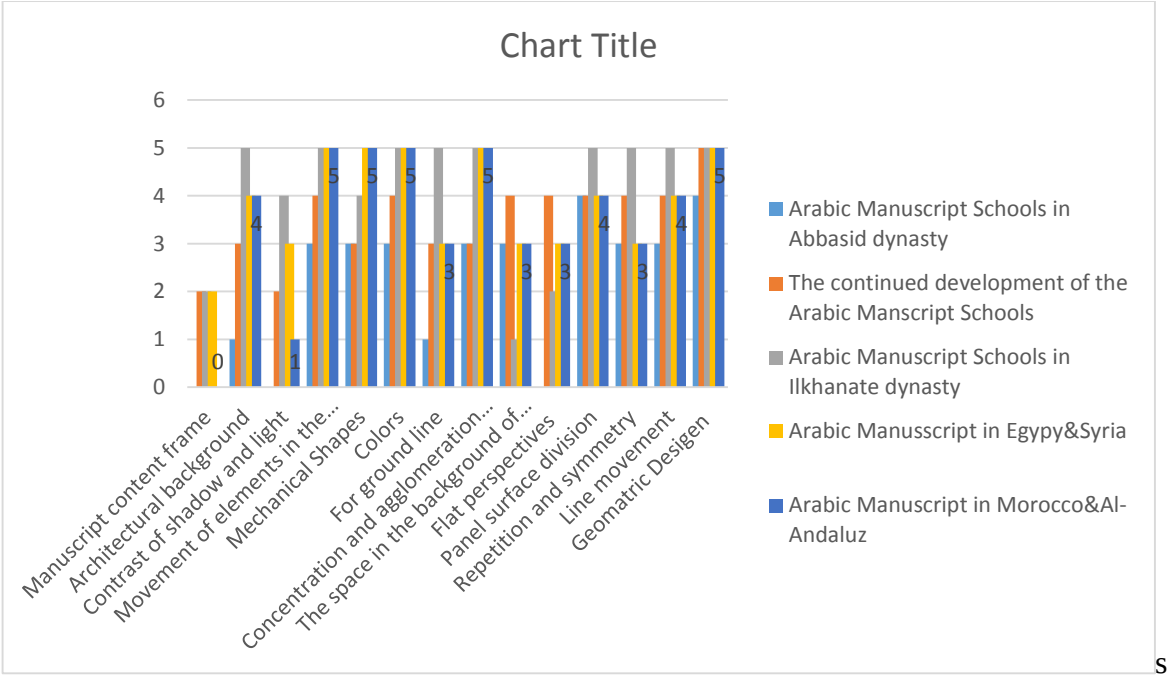
The Bayed and Riyadh manuscript is considered one of the important manuscripts that are attributed to the Arab school in Andalusia and preserved in the Vatican Library (7th century AH / 13th century AD). The story revolves around two lovers who love each other on the Tharthar River, one of the tributaries of the Euphrates. An old sheikh stands on the far right, expressing feelings of sympathy, sorrow, and sadness over Bayed, who is unconscious on the ground near the banks of the river, after singing a poem for his beloved, whom he longs for (Fig. 17, 18), note the movement contrast.

Some of the scenes of Andalusian architecture were depicted in the background of the events and were provided with the movement of the large circular waterwheel (Fig. 17) that waters the plants in the garden. The photographer achieved two human equations between the scene of stillness, sadness, and sorrow around which the tragic story revolves, which seemed to fall through the movement of the flowing edges of the clothes and the whites lying on the ground, and between the magnitude of the movement of the noria wheel and the gradual and harmonious design represented in the architectural backgrounds with semicircular arches, double windows, and covered towers with pointed roofs covered with tiles.

Another picture from the same manuscript shows the lover Bayed sitting on one of the gardens while he is singing and holding a lute, which is one of the inventions of Muslims. Architectural backgrounds appear at both ends of the manuscript, and there are two trees between them. The content duality of the story of the two lovers was reflected in the design elements in both (Fig. 17/18). We find the duality of symmetry in the two trees that come at the top of the manuscript, as well as the two opposite towers, and the block of the landline that corresponds to the writing at the top of the manuscript. We find the illustrator mastered the diversification and interconnection between the elements through the duality of gradation of levels between the parts of the manuscript represented by the old man and the position of the whiteness of the cast on the ground, as well as the duality of gradation in the tower and the waterwheel, which in turn conveys the eye from the circular movement that connects the landline and the high tower. The photographer succeeded in employing the symbolic duality of the story through design and was able to combine movement, stillness, and feelings of grief, expressing the surrounding environment eloquently and concisely, and documenting some of the inventions such as the water wheel and the oud machine, which indicates the richness of that period regarding science, literature, and civilization.

Discussion:

The distinctiveness of the images of Islamic manuscripts in the Middle Ages is that they were not limited to drawing their human, animal, plant, and architectural elements in a descriptive manner, but rather expressed emotions, as they appeared in Islamic schools in Iraq, and the schools that followed them in other stages, which led to the emergence of non traditional, far from reality artworks but yet they were connected to it emotionally and mentally emanating from Islamic teachings. It can be described as one of the aspects of virtual worlds in our contemporary time, with the difference that these manuscripts simulate and affect imaginations and consciences of the viewers, with the aim of establishing human, religious and scientific concepts, wisdom, and stories. Most of designs of Islamic art were formed on a set of complex geometric networks such as the circle, the square, the triangle, the hexagonal shapes, and the intergenerational shapes.



(Fig. 19) Graphical analysis

The study clarified the close relationship between the flourishing of science and knowledge, which led to an impact on the thought, conscience, and minds of the illustrators of Islamic manuscripts schools, which resulted in a general development in the elements and their designs. By analyzing some samples, it was found that:

A. The centrality of building the artwork, which may sometimes take the form of a hierarchical or rectangular geometric structure while preserving the distribution and priority of the elements.

B. The diversity of the use of repetition and reverberation as if it were a rushing sequence by employing the strength of the design lines of the elements, with the difference in their movements between soft and hard, while maintaining balance in the artwork.

C. Diversity in the use of elements and their overlapping and preserving their nature, such as (the mixture of architecture, plants, living organisms, mythical shapes, and other elements that are depicted in a conventional form).

D. Lack of commitment to reality despite drawing inspiration from realistic stories, wisdom, sermons, the Holy Qur'an, and the Sunnah of the Prophet, the painter added from his thought and perception of the unseen world in which he believes.

It is difficult to directly link the specific historical stages between the stages of scientific innovations and the development of the elements of composition design in the schools of Arabic manuscripts, despite its clear influence on the freedom of design with flexible lines, the freedom of expression of reality and imagination, mixing between them, and the use of bright colors without being restricted by night or day. The movement of machines galvanized the imaginations of art and pushed it to dynamism in design and selection of topics, which enriched many manuscripts with different topics.

Recommendations:

- The importance of re-studying the ancient cultural heritage with an in-depth analytical perspective to open the fields of artistic and technical creativity to create new artistic trends with heritage roots to preserve identity and heritage.
- The importance of studying the efforts of Muslim scholars and recognizing their contribution to advancing intellectual, cultural, and civilizational development.
- Awareness of analyzing Islamic images according to the period in which they are contemporary.

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