E-ISSN: 2667-4882
ORTAÇAĞ ARAŞTIRMALARI DERGİSİ, 6/1(2023), s. 300-311 *Araştırma Makalesi/Research Article*
DOI: https://doi.org/10.48120/oad.1264652

Doğu'nun El-Cezeri'si ile Batı'nın Leonardo da Vinci'si Arasındaki İlişki

The Relation Between Al-Jazari of The East and Leonardo Da Vinci of The West

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Başvuru/Submitted: 13.03.2023
Kabul/Accepted: 27.04.2023

Atıf: Kaplan, Kaan, "Doğu'nun El-Cezeri'si ile Batı'nın Leonardo da Vinci'si Arasındaki İlişki", Ortaçağ Araştırmaları Dergisi, 6/1 (Haziran 2023), s. 300-311.
Citation: Kaplan, Kaan, "The Relation Between Al-Jazari of The East and Leonardo Da Vinci of The West", Ortacag Arastirmalari Dergisi, 6/1 (June 2023), p. 300-311.

Öz– El-Cezeri ve Leonardo da Vinci, Doğu'da VIII. yüzyıldan XIII. yüzyıla kadar süren İslami Altın Çağ ve XIV. yüzyıldan XVII. yüzyıla kadar Avrupa'da gerçekleşen Rönesans olmak üzere kendi dönemlerinin en önemli mucit ve mühendislerinden ikisiydi. Her iki bilim insanı da olağanüstü yetenekleri ve mekanik, otomata, su ile çalışan cihazlar ve saat yapımı alanlarına katkılarıyla biliniyordu. Bu çalışma, bu alanlara yapmış oldukları katkılarını karşılaştırır. Ayrıca, bu çalışma buluş ve yeniliğe olan yaklaşımlarındaki benzerlikleri ve farklılıkları analiz edecektir. Birbirlerinden farklı zaman dilimlerinde yaşamalarına rağmen Leonardo da Vinci'nin Cezeri'nin eserlerinden doğrudan mı yoksa dolaylı olarak mı etkilendiği ve eserlerinde kullandığı araçlar arasında benzerlikler olup olmadığı incelenmiştir.

Anahtar Kelimeler– *El-Cezeri, Leonardo da Vinci, Ortaçağ, Mühendislik, Yenilik.*

Abstract – Al-Jazari and Leonardo da Vinci were two of the most noteworthy inventors and engineers of their respective time periods, the Islamic Golden Age that lasted from the VIII. to the XIII. century in the East, and the Renaissance that took place in Europe the XIV. to the XVII. centuries. Both were known for their exceptional talents and contributions to the fields of mechanics, automata, water-powered devices, and clockmaking. This work compares and contrasts their contributions to these fields; it will further explore the similarities and differences in their approaches to invention and innovation. In addition, although they lived at different times, it will also analyze whether da Vinci was directly or indirectly influenced by Al-Jazari's work, and whether there are similarities between the tools he used in his work with those of Al-Jazari.

Keywords– *Al-Jazari, Leonardo da Vinci, Medieval, Engineering, Innovation.*

EXTENDED ABSTRACT

Al-Jazari was an Islamic polymath who lived during the XII. century, in the Islamic Golden Age. He is best known for his book "*The Book of Knowledge of Ingenious Mechanical Devices*", which contains descriptions and illustrations of a wide range of mechanical devices and automata, such as water clocks, fountains, and automata that could perform various tasks. He is considered to be one of the greatest engineers and inventors of the medieval Islamic world, and his work had a significant impact on the development of engineering and technology in the Islamic world and beyond.

By contrast, Leonardo da Vinci was an Italian polymath who lived during the Renaissance. He was a painter, sculptor, architect, musician, mathematician, engineer, inventor, and scientist. He is widely considered to be one of the most important figures in the history of art and science. His notebooks, which contain drawings and ideas for inventions, scientific observations, and artistic studies, are considered to be amongst the most important historical documents of the Renaissance.

Al-Jazari and da Vinci were both incredibly innovative and talented individuals who made significant contributions to the fields of engineering and technology. They designed and built a wide range of mechanical devices and automata, including water clocks, fountains, and machines that could perform various tasks. Additionally, they both made significant contributions to the field of civil engineering, with Al-Jazari designing and building water supply systems and irrigation systems, and Leonardo designing and building bridges, dams, and other structures. Although Al-Jazari and da Vinci lived during different time periods and cultures, their work shows various similarities in terms of their inventive ideas and innovations, especially in the fields of mechanical engineering and automata. However, da Vinci is often credited as being the "father of automata", while almost no credit is given to Al-Jazari. Therefore, this problem should be addressed, where it can be shown, with examples of studies, that da Vinci could well have been influenced by Al-Jazari.

It should be noted that it is not possible to say for certain whether da Vinci was directly influenced by Al-Jazari's work, but it is possible that he may have been influenced by it in some way. Both men were interested in similar fields such as mechanical engineering, automata, and water clocks. A few of the potential ways in which Leonardo da Vinci may have been influenced by Al-Jazari's work are as follows:

1. Through books and manuscripts: Al-Jazari's "*The Book of Knowledge of Ingenious Mechanical Devices*" saw widespread circulation in the Islamic world, and it is possible that copies of the book, or at least descriptions of its contents, may have reached Europe through trade or other means. Leonardo was known to have had an extensive library and was interested in a wide range of subjects, so it is possible that he came across Al-Jazari's book or descriptions of it.
2. Al-Jazari's publications were in Arabic and unknown to the West. However, there is evidence of contact between da Vinci and the Ottoman Empire. The researchers concluded that it is entirely possible that da Vinci was affected in some way by Al-Jazari's work.
3. Through trade and travel: During the medieval period, trade and travel between the Islamic world and Europe was limited but not non-existent. It is possible that traders or travelers may have brought ideas and technologies developed by Al-Jazari to Europe, and that they may have influenced da Vinci and other European inventors.
4. Through the coincident similarities in their interests: Both Al-Jazari and da Vinci were interested in similar fields, such as mechanical engineering, automata, and water clocks, so it is possible that they both independently developed similar ideas and inventions.
5. Through the transmission of knowledge: Al-Jazari's work was known and respected across the Islamic world, and it is possible that some of the ideas and technologies he developed were transmitted to Europe through trade and other means, and that they may have influenced da Vinci and other European inventors.

It could be vital to know whether da Vinci was influenced by Al-Jazari. While it may not change our understanding of his work specifically, understanding the historical and cultural context in which his work was created and whether he was influenced by Al-Jazari or otherwise could offer us a more comprehensive and nuanced understanding of the history of technology and engineering, and the role of different cultures and civilizations in shaping it.

Therefore, in this research, their similarities in terms of their inventive ideas and innovations, especially in the field of mechanical engineering and automata, were compared through their sketches. Whether da Vinci was directly impacted by Al-Jazari's work cannot be determined with certainty, although it is conceivable that he was from our findings.

INTRODUCTION

The Golden Age of Islam, also known as the Islamic Golden Age, as usually regarded as lasting from the eighth to the thirteenth centuries, was a time of outstanding cultural, economic, and scientific advancements in Islam.[1] This period is characterized by the emergence of a number of great Muslim scholars, scientists, and artists who made significant contributions to a wide range of fields, including literature, art, architecture, medicine, mathematics, astronomy, and philosophy.[2]

During this period, the Islamic empire expanded rapidly, encompassing a vast territory stretching from Spain to India.[3] This allowed for the spread of knowledge and ideas across different cultures and regions, leading to a flourishing of culture and scholarship.

One of the most notable achievements of the Islamic Golden Age was the preservation and translation of ancient Greek and Roman texts. Muslim scholars translated works by philosophers such as Aristotle and Ptolemy, as well as medical texts by Galen, into Arabic.[4][5] This helped to preserve the knowledge of the ancient world, and further allowed for the development of new ideas and discoveries. This period also saw the development of advanced scientific and mathematical knowledge. Indeed, Muslim scientists made important contributions to fields such as astronomy, medicine, and mathematics, with their work laying the foundations for later European scientific discoveries.[6][7]

Many of the Islamic Golden Age's writings are thought to have been translated into Latin during the Renaissance and transmitted to European scholars, which helped spur a wave of new findings and inventions in Europe.[8] During the Renaissance, which took place in Europe between the XIV. to the XVII. centuries, there was a renewed interest in the classical knowledge and ideas of ancient Greece and Rome. This led to the development of new ideas and discoveries in fields such as the sciences, arts, and in literature.

The golden age of Islam also saw the rise of great philosophers and scholars like Avicenna, Averroes, and Al-Kindi, whose works had a particular influence on the development of Western philosophy and science. Additionally, in the field of engineering and mechanics, Al-Jazari is the best known for such work.

Ismail al-Jazari, also known as Al-Jazari, was a medieval Muslim polymath and engineer who lived in the XII. century. He was born in 1136 AD in the city of Jazirat ibn Umar, located in modern-day Turkey. Not much is known about his early life, but it is believed that he began studying engineering and mechanics at a young age.[9]

Al-Jazari served as the head engineer at the Artuqids' court in Diyarbakır (in the Mesopotamian area of Jazira).[10] Before passing away in 1206, he finished his magnum work, which contained 100 brilliantly drawn inventive gadgets. Al-Jazari is best known for his work in the field of engineering and mechanics, particularly his book "*The Book of Knowledge of Ingenious Mechanical Devices*", which describes a number of complex machines and mechanical devices that he himself designed and constructed.[11] This book includes fifty devices and forms of machinery which include water clocks, automata, and various other devices that demonstrate a high level of technical skill and ingenuity These machineries can be grouped according to six titles that correspond to their purposes:

1. Ten clocks with water and candles
2. Ten drinking-related figurines and dishes
3. Ten pitchers and receptacles for use in cleansing and blood-drawing before prayer

[1] Ümran Erdoğan, "İslâm'ın Altın Çağında Harezm'de Türkler ve Türk Dili," *Şarkiyat Mecmuası*, no. 38, 2021: 163–81.
[2] Ahmed Renima, Habib Tiliouine, and Richard J Estes, "The Islamic Golden Age: A Story of the Triumph of the Islamic Civilization," in *The State of Social Progress of Islamic Societies* (Springer), 2016, p.25–52.
[3] Howard R Turner, *Science in Medieval Islam: An Illustrated Introduction* (University of Texas Press), 2010, p.118.
[4] Cristina D'Ancona, "Greek into Arabic," 2016, p.11.
[5] Mona Baker and Gabriela Saldanha, "Arabic Tradition," in *Routledge Encyclopedia of Translation Studies* (Routledge), 2009, p.347–56.
[6] YM Faruqi - International Education Journal and undefined 2006, "Contributions of Islamic Scholars to the Scientific Enterprise.," *ERIC* 7, no. 4 2006, p.391–99, https://eric.ed.gov/?id=EJ854295.
[7] Selim Özarslan, "İSLAM DÜŞÜNCESİ VE MÜSLÜMAN BİLİM ADAMLARI," *Munzur Üniversitesi Sosyal Bilimler Dergisi* 8, no. 15 (n.d.), 2019, p.33–46.
[8] Bridget Lim and Aisha Khan, *Avicenna: Leading Physician and Philosopher-Scientist of the Islamic Golden Age* (The Rosen Publishing Group, Inc), 2016, p.6.
[9] Bekir Çırak and Abdülkadir Yörük, "Mekatronik Biliminin Öncüsü İsmail El-Cezeri," *Siirt Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, no. 4 (2016): 175–94; Recep Külcü, "Ortaçağ Anadolu'sunun Büyük Mühendisi El-Cezeri," *Akademia Mühendislik ve Fen Bilimleri Dergisi* 1, no. 1, 2005, p.1–9.
[10] Necmettin Penbegul et al., "Primitive Robotic Procedures: Automotions for Medical Liquids in 12th Century Asia Minor," *Arch Ital Urol Androl* 86, no. 4, 2014, p.300–303.
[11] P Hill, *The Book of Knowledge of Ingenious Mechanical Devices:(Kitāb Fī Ma'rifat Al-Ḥiyal Al-Handasiyya)* (Springer Science & Business Media), 2012, p.276.

4. Ten continuously playing flute machines and ten fountains that intermittently change their forms
5. Five water pumping systems
6. Five different gadgets

His book was written in Arabic where, during the Islamic Golden Age, many works were translated from Arabic into Latin and other languages in order to make the associated knowledge available to European scholars. However, it's not clear when exactly Al-Jazari's book was translated into Latin. It's worth noting that the dissemination of knowledge during the Islamic Golden Age and the Renaissance were complex processes and many works were translated and retranslated multiple times; accordingly, the first translation of a given work can often be difficult to pinpoint. The earliest known Latin translation of the book is believed to have been made in the XV. century, long after Al-Jazari's death.[12] The book considered is considered one of the most important works on engineering and mechanics from the medieval period, and is still studied and referenced by scholars and engineers today. Some historians even say that Leonardo da Vinci might have been inspired by Al-Jazari and his work.[13][14] In this study, Al-Jazari, who left his mark on the Islamic Golden Age, and how his works affected the West during the Renaissance in terms of engineering and mechanics, will be presented.

1. Some Remarkable Inventions of Al-Jazari

Al-Jazari was a pioneering engineer and inventor of his time, and one of his main areas of focus was the design and construction of water-raising machines and water supply systems. One of his most notable achievements in this field was the design and construction of the saqiya chain pump, a water-raising machine that used a series of gears, pulleys, and a chain to lift water from a lower to a higher level.[15] The machine typically consists of a large vertical water wheel that appears to be powered by a donkey or other such animal, which can be seen in Figure 1. The purpose of the donkey's presence in this machine system and its appearance that it powers to the system is actually intended to mislead the audience. The system is powered by the water itself flowing downstream, hidden in a room below the pool, invisible to the observer. A water wheel is attached to the shaft of the machine, and as the water flows over the wheel it rotates and provides the mechanical power to lift the water. The wheel is connected to a series of gears and pulleys that drive a chain. The chain is connected to a series of clay or metal pots or buckets that are used to lift the water. One of the key features of the saqiya chain pump is its efficiency and reliability. The machine is able to lift water to a considerable height, and indeed is able to do so with relatively little energy input. The machine is also relatively simple to construct and maintain, which led to its widespread use throughout the Islamic world.

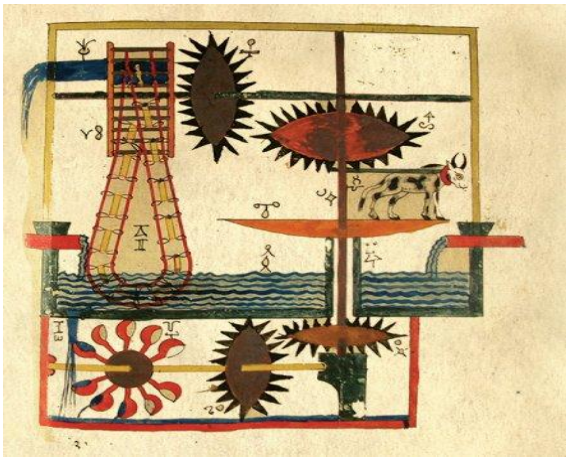

Figure 1. The saqiya chain pump is considered one of the most important of Al-Jazari's inventions and was widely used throughout the Islamic world during the medieval period. The picture is taken from a XIII. century manuscript, Süleymaniye Library, Istanbul

Another of Al-Jazari's water supply invention created using gears and pulleys was the shaduf. The shaduf is a type of water-lifting machine that uses the principle of the Archimedes screw. The machine has a long pole with a bucket or container attached to one end, and a counterweight to the other. The bucket is dipped into a water source,

[12] Amirul Akmal Bin Mohammad Yazid, Mohd Fahmi Bin Md Salleh, and Aminuddin Ruskam, "The Mechanical Engineer: Abu'l–'Izz Badi'u'z–Zaman Ismail Ibnu'r–Razzaz Al Jazari," *Semin. Relig. Sci. Muslim Contrib* 69, no. 4, 2014, p.59–61.
[13] Lotfi Romdhane and Saïd Zeghloul, "AL-JAZARI (1136–1206)," in *Distinguished Figures in Mechanism and Machine Science* (Springer), 2009, p.1–21.
[14] Yazid, Salleh, and Ruskam, "The Mechanical Engineer: Abu'l–'Izz Badi'u'z–Zaman Ismail Ibnu'r–Razzaz Al Jazari, " *Semin. Relig. Sci. Muslim Contrib* 69, no. 4, 2014, p.59–61.
[15] Mahmut Dirik, "Al-Jazari: The Ingenious Inventor of Cybernetics and Robotics," *Journal of Soft Computing and Artificial Intelligence* 1, no. 1, 2020, p.47–58.

such as a well or a canal and, as the operator raises the pole, the water in the bucket is lifted to a higher level. The machine is powered via a water wheel or a man-powered crank, and can be seen in Figure 2.

Al-Jazari described the shaduf as an ancient device that was widely used by the people of Egypt and Mesopotamia. He mentioned the benefits of using shadufs in irrigation and for water management purposes. He wrote that it is simple and easy to construct, and can be made with local materials. It is also relatively easy to operate, and requires minimal maintenance. However, Al-Jazari additionally noted that the shaduf is not as efficient as other water-lifting devices, such as the saqiya chain pump.[16] Nevertheless, the shaduf is considered an improvement over the earlier design of the screw pump and was widely used in the Islamic civilization for irrigation, domestic and industrial water supply, and in many other applications.

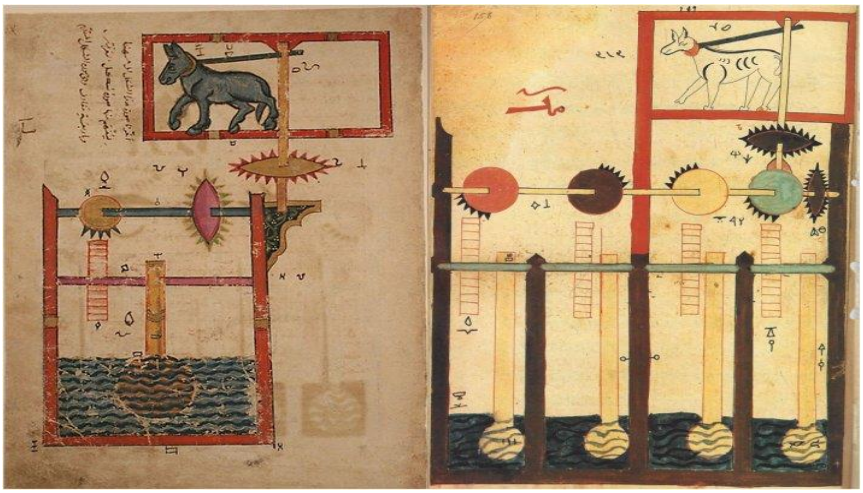

Figure 2. Picture of the shaduf picture from the book of Al-Jazari. The left-hand picture has one ladle whilst the right-hand has four. The pictures are taken from the copy book of Al-Jazari held in the Topkapi Palace.

2. Comparison with Leonardo da Vinci's designs

Leonardo da Vinci, who lived in the XV. and XVI. centuries during the Renaissance and who was one of the most important figures of this period, is known for his exceptional talents as an artist, inventor, and scientist. Additionally, he made significant contributions to the fields of mechanics, automata, water-powered devices, and clockmaking. Some of the mechanisms that both Leonardo da Vinci and Al-Jazari used in their inventions include:

1. Gears and pulleys: Both artists made detailed drawings and notes on gears and pulleys, and used them in a variety of their inventions such as clocks, hoisting machines, water-powered machines, and automata.

2. Crankshaft mechanism: Both used the crankshaft mechanism in their machines; da Vinci used it in pumps and other machines, while Al-Jazari used it in his water-raising machines and automata.

3. Cam mechanism: Both Al-Jazari and da Vinci used cam mechanisms in their automata designs, which were mechanical devices that simulate human or animal movements.

4. Lever and linkage mechanisms: Both used lever and linkage mechanisms in their inventions, such as in automata, pumps, and other machines to transfer movement and power.

5. Water-raising machines: Both Al-Jazari and da Vinci designed water-raising machines, such as the saqiya chain pump and reciprocating pumps, respectively.

6. Clock mechanisms: Both Al-Jazari and da Vinci made detailed drawings and notes on clock mechanisms, and both designed weight-driven and spring-driven clocks.

7. Automata: Both Al-Jazari and da Vinci designed automata which, as noted in point 3, simulate human or animal movements.

2.1 The application of gears and pulleys of both inventors

[16] David A King, "' The Book of Knowledge of Ingenious Mechanical Devices: Kitab Fi Macrifat Al-Hiyal Al-Handasiya by Ibn Al-Razzaz Al-Jazari' by DR Hill," *History of Science* 13, no. 4, 1975, p.284–89.

As can be seen, gears and pulleys were the important component of Al-Jazari's designs; indeed, he improved and additionally gave different shapes to these parts in order to fit in various machinery. For da Vinci, who was an inventor and engineer, gears and pulleys played vital roles in his inventions.

Leonardo's notebooks, which contain his drawings and notes, are filled with detailed drawings and notes on gears and pulleys, as well as other mechanical devices and machines. He was particularly interested in the mechanics of gears and pulleys and made many detailed drawings and notes on the subject.[17] Gears and pulleys were used in his hoisting machines designs, such as the pulley-driven winch, double-gear hoist, and a crane that used gears and pulleys to lift loads. However, the most important ones were used for water-powered machines such as the water-powered saw, water-powered hammer, and water-powered grinding machine, all of which used gears and pulleys to transfer power. He was particularly interested in understanding the principles of gear operation and the ways in which gears could be used to transfer power and motion.

One of Leonardo's most notable contributions to the field of gears is his analysis of the geometry of gear teeth. He made drawings of different types of gear teeth and studied the ways in which they interacted with one another. In Figure 3, contact between teeth and notches from his drawings and their similarity to Al-Jazari's water pump invention can be seen. He additionally made detailed notes on the principles of gear operation, including the importance of proper tooth spacing and the effects of different gear ratios. According to general opinion, both from the past and the present, the first person to use hydraulic and mechanical gears was da Vinci.[18]

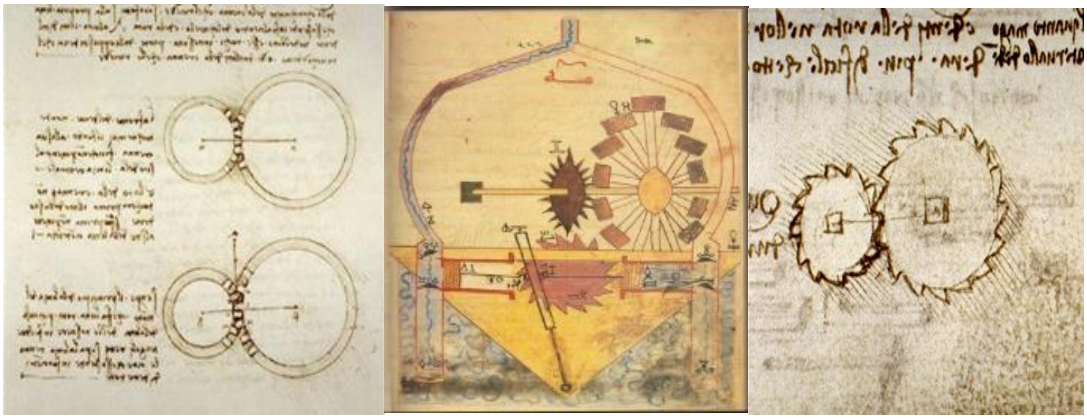

Figure 3. The left-hand drawing shows the teeth and notches, whilst the right-hand shows the asymmetrical teeth (peg teeth), from Leonardo da Vinci's drawings. The pictures are taken from the Museo Galileo at Florence. The central drawing is an image of Al-water Jazari's pump that was obtained from his copy book at the Topkapi Palace

2.2 The application of the crankshaft of both inventors

Al-Jazari is credited with the development of the crankshaft, which is a mechanical component that converts linear motion into rotary motion. He used the crankshaft in a number of his inventions, particularly in his water-raising machines.[19] In "*The Book of Knowledge of Ingenious Mechanical Devices*", Al-Jazari described the use of a crankshaft in his saqiya chain pump in Figure 1. Al-Jazari additionally used the crankshaft in his automata; for instance, he described the use of a crankshaft in his elephant clock, which was a mechanical elephant that could move its head, trunk, and tail.

From the perspective of da Vinci, he studied the ways in which the crankshaft could be used in a variety of mechanical devices and machines. One of the most notable examples of da Vinci's use of the crankshaft is in his designs for a reciprocating pump and a double-acting pump.[20] He made drawings of pumps that used a crankshaft to convert the linear up-and-down motion of a piston into rotary motion, which was used to drive a water wheel or other power source. Both Al-Jazari and da Vinci made significant contributions to the development of the crankshaft mechanism, examples of which can be seen in Figure 4.

[17] Mark Rosheim, *Leonardo's Lost Robots* (Springer Science & Business Media), 2006, p.63.
[18] Larry W Mays, "A Brief History of Water Technology during Antiquity: Before the Romans," in *Ancient Water Technologies* (Springer), 2010, p.1–28.
[19] Abdullah Uzun and Fahri Vatansever, "Ismail Al Jazari Machines and New Technologies," *Acta Mechanica et Automatica* 2, no. 3, 2008, p.91–94.
[20] G J Hollister-Short, "Antecedents and Anticipations of the Newcomen Engine," *Transactions of the Newcomen Society* 52, no. 1, 1980, p.103–17.

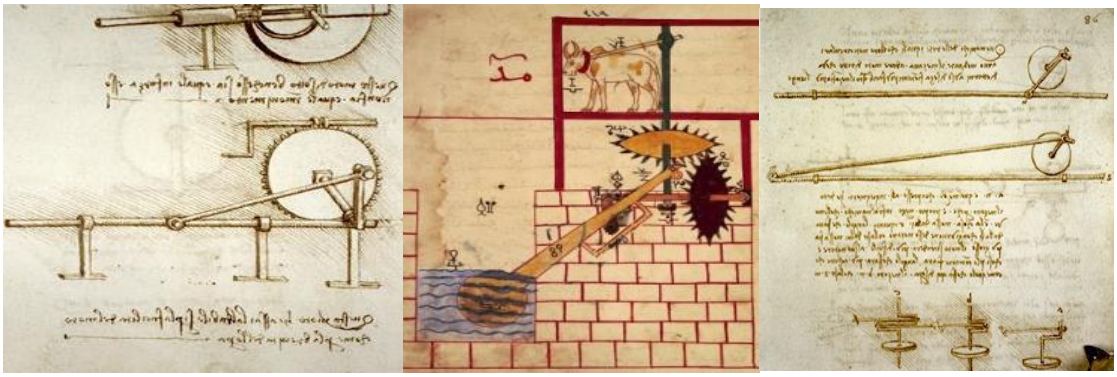

Figure 4. The left-hand picture shows a crankshaft driven by worn screw and toothed wheel whilst the right-hand image shows two different crankshaft systems, both of which are taken from da Vinci's drawings. The central image shows Al-Jazari's crankshaft mechanism, as taken from the Chester Beatty Library in Dublin

Al-Jazari developed the mechanical components that helped the development of a water supply system at a time when people still mostly drew their water from wells and rivers. In contrast to da Vinci, who was well-known and talented for the designs he drew in his notebooks, Al-Jazari was able to effectively design a mechanical system that was operable and functioning and that was controlled by the gadgets he designed.

2.3 The application of the camshaft of both inventors

Both Al-Jazari and da Vinci used cam mechanisms in their inventions. A camshaft is a mechanical component that converts rotary motion into linear motion, and can be used to control the timing and duration of various operations in a machine. Al-Jazari used camshafts in his other automata designs, such as the boat with four automated musicians that play music on a water organ that can be seen in Figure 5. The boat is powered by a water wheel, which is connected to a series of gears and camshafts that control the movement of the musicians, and the operation of the water organ. Furthermore, the boat was equipped with a series of lights that can be lit and extinguished by the movements of the camshafts. Conversely, da Vinci made drawings of camshafts that incorporated gears and pulleys, which allowed him to vary the speed and torque of linear motion. In Figure 5, the implementation of the camshaft by da Vinci can be seen.

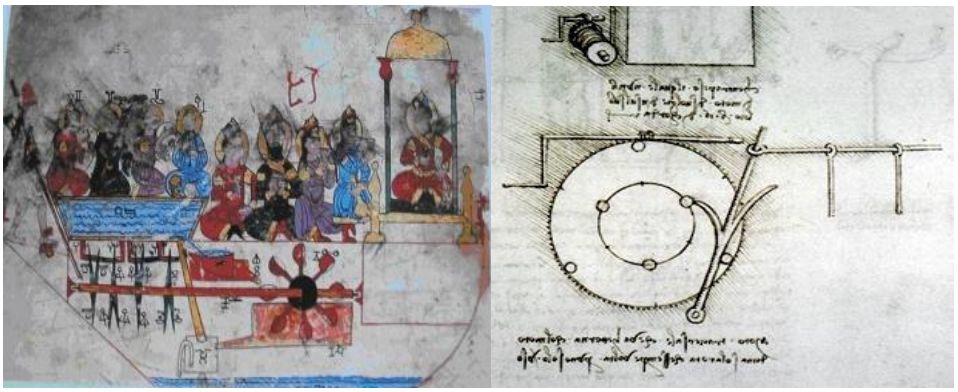

Figure 5. Applications of the camshaft by both engineers. The left-hand image shows Al-Jazari' music boat and is taken from the Topkapi Palace Library. The right-hand image was drawn by da Vinci, and is taken from the Museo Galileo at Florence

2.4 The weight-driven mechanisms of both inventors

Both Al-Jazari and da Vinci used weight-driven mechanisms in a number of their inventions, particularly in their clocks and automata designs. They used weight-driven mechanisms to convert the force of gravity into rotary motion. Figure 6 shows two examples of weight-driven mechanisms by both inventors.

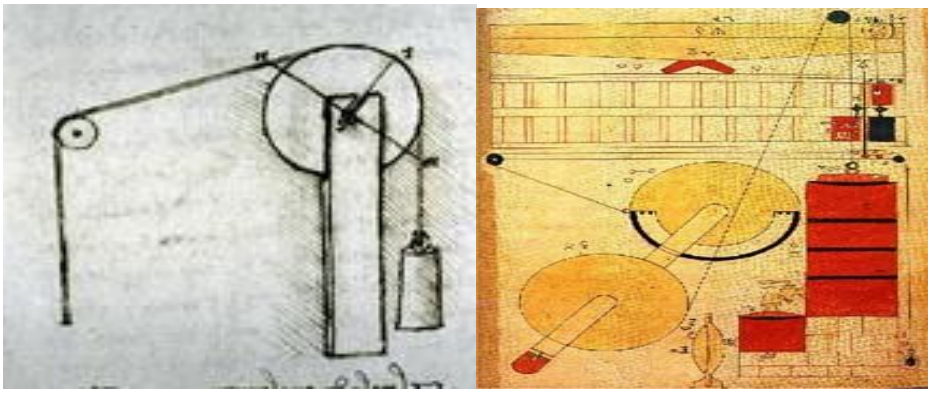

Figure 6. The left-hand drawing is by da Vinci and is taken from the Museo Galileo at Florence. The right-hand image depicts Al-Jazari's invention, and is taken from the Topkapi Palace Library

2.5 The water clock designs of both inventors

Although there is no evidence that da Vinci ever built a water clock, he made drawings of a variety of water clock designs and made extensive notes on the subject. His water clock designs were based on the principle where a container filled with water would be allowed to empty out through a small hole; the time taken for the container to empty would be used to measure time. A drawing of such can be seen in Figure 7.[21] Conversely, Al-Jazari's Elephant Clock is a weight-driven mechanism that depicts an elephant moving its head, trunk, and tail, and also strikes a bell every hour. The clock is powered by a set of weights suspended from the frame of the clock. As the weights fall, they turn a series of gears and camshafts that control the movement of the elephant and the striking of the bell. A drawing of the Elephant Clock is given in Figure 7.

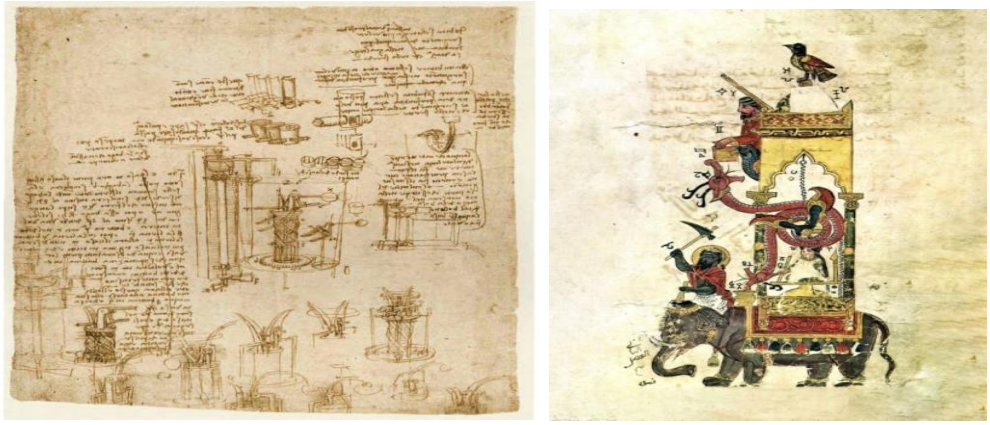

Figure 7. Clock designs by both inventors. Neither was able to bring their clocks to life in their own time, with them remaining plans in their books

CONCLUSION

While the Islamic Golden Age and the Renaissance were distinct historical periods, there were connections and similarities between the two that have led to the idea that the Islamic Golden Age may have influenced the Renaissance. However, it's important to note that there were many other factors that contributed to the Renaissance, and as such the Islamic Golden Age was just one of many influences on the European intellectual and cultural movement.

Al-Jazari is considered a pioneer of the field of automata, and his work is considered to be one of the most important contributions to the field of engineering during the medieval period. This refutes a long-held notion that the much-honored genius Leonardo da Vinci was the first to comprehend and make use of mechanical gears and hydraulics. Al-Jazari should receive credit for the discovery as he developed the strategy more than two centuries before da Vinci; it is only because Al-Jazari's publications were in Arabic, and thus unheard of in the West, that this is not the case. Nonetheless, it is known that da Vinci had access to various books and manuscripts from the Islamic world, including those on mechanics and engineering, which could have included works by Al-Jazari. Furthermore, it is well-documented that there was a flourishing trade and cultural exchange between the Islamic world and

[21] S Brillarelli et al., "Digital Experience of the Work of Vitruvius and Leonardo," in *IOP Conference Series: Materials Science and Engineering*, vol. 949 (IOP Publishing), 2020, p.12041.

Renaissance Europe during Leonardo's time. Italian merchants and artists frequently traveled to the Islamic world, while Ottoman diplomats, scholars, and artisans visited Italy and other parts of Europe. It is likely that da Vinci was exposed to Islamic technological and scientific achievements through such channels of communication. In addition, the similarity between some of Leonardo's and Al-Jazari's mechanical inventions, such as the use of gears and pulleys, suggests that there may have been some indirect influence. In 1502, da Vinci created a sketch for Ottoman Sultan Beyazid II of Istanbul that included a single span (220-meter) bridge. This finding alone demonstrated that da Vinci and the descendants of Sultan Artuq, who was Al-Jazari's employer, had correspondence during that time.

Acknowledge

I would like to thank the “Sultans of Science” exhibition at Müzeyyen Erkul Gaziantep Science Center, where I was able to examine the most important works of Al-Jazari on site.

Yayım Tarihi	26 Haziran 2023
Hakem Sayısı	Ön İnceleme: Bir İç Hakem (Editör-Yayın Kurulu Üyesi) İçerik İncelemesi: Üç Dış Hakem
Değerlendirme	Çift Taraflı Kör Hakemlik
Benzerlik Taraması	Yapıldı-Turnitin
Etik Bildirim	ortacagarastirmalaridergisi@gmail.com
Çıkar Çatışması	Çıkar çatışması beyan edilmemiştir.
Finansman	Herhangi bir fon, hibe veya başka bir destek alınmamıştır.
Telif Hakkı & Lisans	Yazarlar dergide yayınlanan çalışmalarının telif hakkına sahiptirler ve çalışmaları CC BY-NC 4.0 lisansı altında yayımlanır. https://creativecommons.org/licenses/by-nc/4.0/deed.tr

Date of Publication	26 June 2023
Reviewers	Single Anonymized - An Internal (Editor board member) Double Anonymized - Three External
Review Reports	Double-blind
Plagiarism Checks	Yes - Turnitin
Complaints	ortacagarastirmalaridergisi@gmail.com
Conflicts of Interest	The Author(s) declare(s) that there is no conflict of interest.
Grant Support	No funds, grants, or other support was received.
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