RESEARCH ARTICLE

Scientific projects of Nasir al-Din al-Tusi

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Abstract
The topic "Modern educational technologies" is intended for pedagogical workers of educational institutions. The presented material may be useful to teachers for the rational organization of the educational process using modern educational technologies. The "Modern Educational Technologies" distance learning unit is designed for 6 hours and includes the study of the following questions: "The concept of"pedagogical technology", the prerequisites of its emergence of the term", "Classification of technologies", "Structure of pedagogical technology", "Features of pedagogical technology and technological processes". The structure of the block consists of a theoretical material that reflects the nature and features of the technological approach to learning, the characteristics of individual technologies, as well as questions for self-control and the final test on the material under consideration. The block of distance learning "Modern educational technologies" contains glossary and a list of references. The student, while studying the topic of "Modern educational technologies", will receive not only theoretical knowledge, but also master practical skills aimed at the effective organization of the educational process using modern educational technologies.

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Introduction

Nasir al-Din al-Tusi is considered one of the most important scientific and philosophical figures of the seventh century AH. He had a significant influence on Arab-Islamic civilization, not only through his writings and commentaries in various fields of science and art, including philosophy, mathematics, logic, astronomy, music, and ethics. His greatest influence was also in He made special scientific contributions in the fields of astronomy and mathematics. He was the first to establish trigonometry as a science independent of astronomy, as most historians believe (Al-Jubouri, 1941, p. 11). He also criticized Ptolemy's Almagest and highlighted the idea that the sun is the center of the solar system, not the earth, as was prevalent before him (Al-Difa', p. 19). These contributions and successes did not come out of nowhere. He was not just a scholarly researcher preoccupied with research and writing, but was also a political figure who held leadership positions in the Mongol state and oversaw the management of endowments. He leveraged his close relationship and closeness to the Mongol leader, Hulagu, to build important scientific projects that played a major role in teaching science, preserving Islamic scientific heritage from loss, and developing the scientific movement in Arab-Islamic civilization in the seventh century AH, despite the political, cultural, and social events that century witnessed, perhaps the most important of which were The fall of Baghdad to the Mongols and the subsequent destruction and devastation of the Abbasid state had a negative impact on the development of science in Arab-Islamic civilization. This prompted al-Tusi, in addition to his scientific and philosophical research, to undertake important scientific projects, allocating vast sums of money to them and selecting the most distinguished scholars in various specialties. He hoped to salvage what could be salvaged amidst this tense political landscape and the problem raised in this article.

What were al-Tusi's scientific projects? And what were their implications for the scientific movement of his time?

Before answering this question, we will briefly discuss Nasir al-Din al-Tusi's life and his writings. We will then discuss his scientific achievements, which can be summarized as three major projects: the Maragheh Observatory, the Observatory Library, and the Scientific Complex.

2.Al-Tusi's Life and Upbringing:

2.2 His Birth, Upbringing, and Death:

Nasir al-Din al-Tusi is Muhammad ibn al-Hasan, nicknamed Abu Ja'far, and his famous name is al-Tusi, in reference to Tus (al-A'sam, p. 49). He was born on Saturday, the eleventh of Jumada al-Ula, 715 AH, corresponding to 410 AD (al-A'sam, p. 47). He grew up in the early years of his life in the care of his father, Muhammad ibn al-Hasan, and his maternal uncle, the sage Fadil Baba Afdal al-Kash, who was known as the philosopher. It is possible that he grew up in a scholarly family that had a significant influence on his personality (Salman, 2017, p. 20). When he reached the age of fifteen, he migrated to Nishapur, the city of knowledge and philosophers, in order to acquire knowledge and learning in an organized manner. He spent a period there extending from 401 AD to 444 AD, one of the most fruitful periods of his cultural life. Where he studied under Mu'in al-Din al-Misri, Farid al-Din al-Damad and Kamal al-Din al-Mawsili, during which he focused on studying jurisprudence, philosophy, and mathematics (Salman, 2017, p. 7). However, with the fall of Nishapur to the Mongols, al-Tusi returned to the city of Tus and spent six years there, from 1444 to 1441. He spent this time isolated from the public, devoting himself to his books. He practiced self-education, relying on his own study and reading until he became a specialist in philosophy, nature, ethics, and politics. He then migrated again to the Ismaili fortresses and remained there for a long period, from 1441 to 1477. This was the most important period in al-Tusi's life, during which he wrote most of his works on philosophy, mathematics, astronomy, and ethics. (Salman, 2017, p. 7). The Ismaili fortresses, in turn, were not spared attacks.

The Mongols, which prompted al-Tusi to contact Hulagu, the Mongol leader, to secure his life and future from their brutality. He got what he wanted when the Alamut fortress, the last Ismaili fortress, fell and Rukn al-Din, the Ismaili leader, surrendered. Al-Tusi joined the Mongols to protect them from their destruction and began a new era alongside Hulagu (Al-A'sam, p. 91). He became his advisor and correspondent. In the middle of the seventh century AH, specifically in the year 177 AH, the Mongol conquest of Baghdad began. On the fifth day of Safar in the year 177 AH, Baghdad fell and Caliph al-Musta'sim was killed. Al-Tusi was a witness and present at this catastrophe. Al-Tusi continued with Hulagu and took over the Ministry of Endowments and the inspection of the country's affairs from him. Al-Tusi inspected the conditions of the country and its people, trying to reform them. From a scientific perspective, he persuaded Hulagu to build an observatory in Maragha and worked hard to collect books from all over Iraq until he established a huge library that contained On many books in philosophy and various sciences (Salman, 217 p. 22).

Al-Tusi remained in Hulagu's service in Maragheh after the fall of Baghdad until Hulagu's death in Rabi' al-Awwal 663 AH. He was succeeded as Mongol leader by his son, Aba Qa Khan (Salman, 2017, p. 22). A strong relationship existed between him and al-Tusi, which al-Tusi exploited to care for the observatory's scholars and students, granting each one a monthly salary and appointing them to positions appropriate to their status within the observatory. Al-Tusi traveled to Khorasan and Qahstan in 665 AH, accompanied by Qutb al-Din al-Shirazi, then returned to Maragheh in 115 AH (Radwa, 2017 AH, p. 71-70). He also traveled to Iraq twice in 114 AH to collect books for the observatory's library. He also traveled to Baghdad several times, the last of which was in 154 AH, accompanied by Aba Qa Khan, the Mongol leader. Abakhan did not stay in Baghdad for long, as he quickly returned to Maragha, while al-Tusi remained in Baghdad, where he fell ill and his illness worsened (Radwa, 1419 AH, p. 52), and he died as a result of that illness.

On the evening of Monday, the eighteenth of Dhul-Hijjah, the Day of Ghadir in the year 672 AH, corresponding to the year 1274 AD, at the age of fifty-seven, his body was escorted by the owner of the Diwan, Shams al-Din al-Juwayni, the minister, and the scholars of Baghdad, in addition to a large crowd of people, and he was buried in Kadhimiya (al-Husayni, 2005, p63).

2.2 His works:

Al-Tusi was distinguished by his many works on wisdom, geography, physics, music, calendars, logic, mathematics, and ethics. He also worked to explain the works of philosophers who preceded him. Al-Tusi's works and treatises on mathematics, astronomy, and other branches constitute a valuable library that increased human scientific wealth and pushed it toward advancement and progress (Tuqan, Arab Scholars and What They Gave Civilization, p. 225). It has been mentioned that his works exceeded 71 books (Thamer, 1983, p. 82). Among these works, we mention the following:

1.Tahrir al-Majisti: This book is by Ptolemy and was edited by al-Tusi. It includes thirteen articles and was completed in 122 AH.

2. Tahrir Usul al-Hindasa: This is a book by Euclid, edited by al-Tusi and also called Tahrir Usul al-Hindasa. (Al-Amin, 1997, p. 21)

3. Zubdat al-Idrak fi Hayat al-Aflaak: This is a brief treatise on the science of astronomy.

4. al-Tadhkira al-Nasiriyya: It is considered one of the most important books written on astronomy and the most comprehensive of its issues. It was explained by many scholars of its time.

5. Al-Zij al-Ilkhani: This is a book written by al-Tusi in Persian. It includes four articles. The first article deals with knowledge of dates, the second with knowledge of the movement of the planets and their positions in longitude and latitude, the third with knowledge of times, and the fourth with the rest of the astrological works and tables of planetary movements (Al-Amin, 1997, p. 26).

6. Basis of quotation: It is considered one of the greatest and most important books on logic after Al-Shifa. It was written in Persian and was composed in 124 AH. It includes nine articles.

7.Kitab al-Tajrid or Tajrid al-Aqa'id: This is the first book to be classified according to Shi'a beliefs and doctrines. It is arranged according to six objectives or topics.

8. Summary of the Collector or Critique of the Collector: This work deals with theology and is a commentary and critique by al-Tusi of the book "The Collector of the Thoughts of the Ancients and the Moderns" by Imam al-Razi (al-Amin, 1997, p. 28).

9. Explanation of the Signs: This book is based on the Signs and Warnings of Ibn Sina. A large group of scholars have commented on and clarified it, including Imam Fakhr al-Din al-Razi, who raised many objections to Ibn Sina. Nasir al-Din al-Tusi also commented on it, responding to the objections raised by al-Fakhr al-Razi. It took al-Tusi approximately twenty years to compile, completing the commentary in 122 AH (al-Amin, 1997, p. 30).

3.Maragheh Observatory

3.1 Construction and Engineering of the Observatory

The establishment of observatories in the Arab-Islamic world played a major role in the advancement of astronomy among them. The idea of establishing observatories dates back to the Greek era, as they were the first to observe planets with instruments. The Alexandria Observatory, built in the thirteenth century BC, is considered the first observatory written about. Among the Arabs, the observatory is considered to be the al-Ma'mun Observatory in Baghdad and Damascus, the observatories of the Fatimid Caliphs al-Aziz and al-Hakim bi-Amr Allah in Cairo, the observatory of Adud al-Dawla in the garden of his palace in Baghdad, and the observatory of Malik Shah the Seljuk in Nishapur in eastern Iran (Honka, 1991, pp. 90-94). Several observatories subsequently appeared in many regions of the Arab-Islamic world. Among the most important and famous of these observatories is the Maragha Observatory, built by Nasir al-Din al-Tusi in Maragha (Touqan, Arab Scientific Heritage in Mathematics and Astronomy, 1992, pp. 17). The observatory is located on a hill. In the suburb of Maragheh, this hill extends along its length to midday. It has a flat top, approximately 400 meters long and 150 meters wide (Aydin, 1993, p. 412). Its construction began in the month of Jumada al-Ula in the year 175 AH, i.e., in April-May 1971 AD (Aydin, 1995, p. 412).

Most historians confirm that the idea of building the observatory was invented by al-Tusi. He was deeply interested in astronomy, and the idea of an observatory had preoccupied him for a long time. However, the appropriate time to implement it did not exist due to the political circumstances at the time, and the subsequent Mongol invasion of Baghdad. After Hulagu consolidated his grip on Baghdad and Baghdad and its surrounding areas fell into the hands of the Mongols, al-Tusi proposed the idea of building an observatory to Hulagu. This idea was accepted and welcomed by him. He even ordered that all the observatory's needs be paid from the treasury and from the revenues of the cities to manufacture and supply the observatory's instruments. He also placed all the endowments of his cities at al-Tusi's disposal, so that he could invest tenths of them in covering the observatory's expenses (Radwa, 1419 AH, p. 20).

The observatory's construction costs were considerable, especially since it housed many of the famous scholars of that era who contributed to its construction and management under the leadership of al-Tusi. It also contained many advanced instruments that greatly contributed to the observatory's fame and elevated its status.

The observatory's architecture consists of a two-story building containing, in its center, a rectangular building rising above the circular building. Its length is equal to half the radius of a quarter circle, five cubits or longer. This is because the height from the end of the opening through which the sun shines on the quarter circle at midday to the ground is half the radius of the quarter circle. There is another long opening, two or three cubits long, above the opening that represents the roof of the building. The height of the two floors is fourteen cubits, with each of them seven cubits long. The rectangular roof contains six holes. The width of the building from the door to the inside is approximately four and a half cubits. There is a corridor in the middle at both ends of the quarter circle, used as a passageway to the end of the building. There is a staircase at both ends of the square so that the observer can ascend to the top where he can see the place where the sun shines, where the sun is at its highest point. The length of the distance from the end of the opening through which the sun rises on the quarter circle at midday is twenty-three and a half cubits, while the outer circumference is one hundred and eighty-six. Arm (Radwa, 1419, page 47).

3.2 Observatory Scholars:

Al-Tusi was not the only scholar responsible for building and operating the observatory. He chose a group of scholars from across the Islamic world, as this massive project required a group of scholars specializing in astronomy and mathematics.

They cooperated with each other to complete it, oversee its management, and achieve the desired goals of its construction. Al-Tusi mentioned in his book, "The Ilkhani Zij," that he gathered a group of wise men to build the observatory, including: Al-Mu'ayyad al-Ardi from Damascus, who had extensive knowledge of geometry and observational instruments; Al-Fakhr al-Maraghi, who was in Mosul, where he was a physician and professor of mathematics; Al-Fakhr al-Khalati, who was in Tbilisi and specialized in mathematical sciences; and Al-Najm Diberan al-Qazw (Al-Husayni, 2005, p. 141), who was a scholar of theology and logic.

It is said that Hulagu had a number of Chinese astronomers brought from China to the Maragheh Observatory, including an astronomer named "Fau-Min-Ji." These Chinese astronomers contributed their knowledge and experience in astronomy and the Chinese calendar to other scholars at the observatory. This, according to Sarton, demonstrates the universality of the Maragheh Observatory. The Ilkhanid tables were also popular not only in the Islamic world but also in China (Aydin, 1995, p. 41).

Other scholars who contributed to the construction of the observatory were not mentioned by al-Tusi alongside the previous scholars, but were added by historians. Among them are Najm al-Din al-Katib al-Baghdadi, who was skilled in observation, mathematics, and engineering; Muhyi al-Din al-Maghribi, who specialized in observation and mathematics; Qutb al-Din al-Shirazi; Sheikh Kamal al-Din al-Iji; Najm al-Din al-Shami; Shams al-Din al-Sharwani; Hussam al-Din al-Shami; and others (Radwa, 201 AH, page 20, where they formed a collective body that played a joint role in building the observatory, led by al-Tusi, who covered their expenses and the observatory's expenses, which came from the treasury and from the revenues of other cities, as we mentioned earlier.

3.3 Instruments of the Maragheh Observatory:

The Maragheh Observatory contains many astronomical instruments used to determine the movements of stars and planets. Observation results cannot be accurate without these precise instruments. The observatory has many tools for observing the movements of stars and planets, including: the annular sphere, the heliopause, which determines the azimuth of planets, and the astrolabe, an instrument used in astronomy to determine the altitude of the sun, prayer times, and the direction of the qibla (Salman, 1995, p. 42-47). The exhibition presents the instruments he made or commissioned as its chief engineer. These include (Aydin, 1995, p. 41-41):

- A wall quadrant with a radius of approximately 291 centimeters, graduated to measure minutes. It is perhaps the first instrument made in Maragheh. It was used to precisely determine the latitude of Maragheh and the inclination of the zodiac. It contains a pillar. It has two viewing targets.

- It has a ring with five rings and a bracket, with the outer diameter of the farthest ring, the meridian ring, being slightly less than 100 centimeters.

- A solstice measuring instrument consisting of a ring with a diameter of 470 centimeters, installed in the meridian circle and equipped with a bracket.

- An instrument for measuring the equinoxes, consisting of a ring representing the meridian and a vertical ring representing the equator.

- A two-hole instrument for measuring the visible diameters of the sun and moon to observe solar and lunar eclipses.

An azimuth ring equipped with two quadrants and brackets for measuring the angles of the sun. The display does not mention its size, but indicates that it should be as large as possible. Only one model was made.

- A two-pronged instrument for measuring planetary parallax, equivalent to measurements made using a ring with a radius of 471 cm.

- An instrument for determining the azimuth and the sine of the complement of the angle of elevation.

- An instrument for measuring sine and cosine, i.e., an instrument used to measure the azimuth and sine of the angle of elevation. Only one model was made.

- The complete instrument, similar to the two-pronged instrument for measuring planetary parallax, but not fixed at the meridian and can rotate about a vertical axis. It can be said that the Maragheh Observatory, with its large scientific body and library containing numerous works in various sciences, was not merely an institution for astronomy research.

Rather, it was a scientific academy that provided great opportunities for the exchange of ideas and communication among scholars. It also included many prominent scholars who contributed to the observatory's activities, including teaching science and writing books. They also succeeded in developing astronomical systems that were alternative to Ptolemy's, and were truly among the first to spark the Copernican revolution in the sixteenth century AD (Salman, 2017, p. 410).

4. Maragheh Observatory Library

Among the important scientific achievements that played a major role in preserving the Arab and Muslim heritage of books and works in various sciences was the construction of a huge library alongside the observatory and the scientific complex. Al-Tusi knew how to take advantage of his closeness to Hulagu and his many The funds were in his hands, and he could dispose of them as he pleased. Al-Tusi worked to establish a large library for the observatory, containing a wide variety of books on various sciences. Most of the books were brought from Iraq, Hillah, Kufa, and Mosul, and placed in this library, which belonged to the observatory's house. This library contained more than four hundred thousand books (Salman, 2017, p. 41). This library also included books written at the observatory, given that it housed a large scientific body of scholars and students who contributed significantly to the development of the observatory's knowledge and sciences. Al-Tusi also encouraged his scholars and students, lavishing them with funds in exchange for the noble work they had done for the observatory. It is clear that this library deserves to be described as an independent institution, and there is no doubt that it played a significant role in the development of scientific and philosophical thought among the scholars and philosophers housed at the Maragheh Observatory, given that writing books was a priority for the observatory's astronomers (Aydin, 1995, p. 11).

5.The Scientific Academy:

Al-Tusi established a scientific academy in Maragheh, alongside the observatory and the library, which included the most prominent scholars of the era. This academy was considered a new event in Arab-Islamic civilization, as it had not existed before, and was only comparable to the ancient Greek academies. He established special rules governing this academy, specifying the conditions that must be met by its scholars and students, and scheduling all its regular meetings, research, and lessons to be discussed. He also worked to teach various types of sciences. Among its members were: Shams al-Din ibn Muhyi al-Din, Ibn al-Ghuti, al-Iji, al-Khalati, Shams al-Din al-Sharwani, Mu'ayyad al-Din al-Ardi, Najm al-Din al-Qazwini, Fakhr al-Din al-Maraghi, Muhyi al-Din al-Maghribi, and others (Thamer, 1983, p. 15). Al-Tusi held the first scientific conference in which scholars of the East gathered.

And the West, in his observatory in Maragheh, to participate with him in the astronomical observatories he established there, and to review the scientific results he had reached (Al-Difa', p. 19). Al-Tusi covered the expenses of the complex, including expenses, shelter, and housing for scholars and students alike. He paid salaries to all scholars and students, each according to his position and knowledge. Al-Tusi assigned three dirhams per day to each philosopher, one dirham to each jurist, and half a dirham to each hadith scholar. Therefore, people flocked to the Maragheh School, especially to the institutes of philosophy and medicine, more than to jurisprudence and hadith. These sciences had been taught secretly and were not encouraged to study them. This is considered a major achievement credited to al-Tusi, who encouraged learning and brought scholars together in one place to contribute to the transmission of knowledge and sciences to generations. Al-Tusi's call found a great response, not only from Arab scholars, but also from non-Arabs and from various places, from Damascus to Mosul. From Qazvin and other Islamic countries (Nima, p. 721), Abaqa frequently and repeatedly provided financial assistance to approximately one hundred students who were students at the Observatory School, students of Nasir al-Din al-Tusi, where education was organized and all evidence shows that it was official and not merely an extension of private education (Aydin,1995; p. 117).

Conclusion

Among al-Tusi's scientific achievements, which played a significant role in Arab-Islamic civilization, was the construction of the Maragheh Observatory, where many astronomers and mathematicians of that era worked from all over the Islamic world. The Observatory's vast scientific library played a significant role in the advancement of Arab-

Islamic sciences. Among the achievements credited to this observatory is al-Tusi's authorship of his book "Ilkhanid Zij" in 1271 AD.

Until recently, he remained a reliable source of European astronomical studies (Salman, 2017, p. 90). He also played a role in protecting many rare scientific works and books from destruction during the Mongol invasion of Baghdad by placing them in the Maragheh Library. He also opened his scientific complex to scholars and students, ensuring their comfort, providing them with financial assistance, encouraging them to continue their pursuit of knowledge, and holding scientific meetings and symposia. All of this had a significant impact on raising the level of knowledge and preserving Islamic heritage from loss, especially in light of the ongoing conflict between Muslims and Mongols.

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