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The Evolution of Astronomical Instruments from the Classical Era to Digital

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ABSTRACT

The science of astronomy is closely tied to the development of astronomical instruments, which evolved in tandem with the dynamics of Islamic civilization. Classical instruments such as astrolabs, rubu' mujayyab, and mizwala play a crucial role in observing celestial bodies, determining the direction of the qibla, prayer times, and the beginning of the lunar month. This research aims to examine the evolution of astronomical instruments from the classical era to the digital era, as well as identify actual problems related to their understanding and use. The research method employed is a literature review, which involves studying classical books, Islamic science history literature, and contemporary scientific articles. The results of the study show that the development of astronomical instruments is divided into four phases: the classical era, with the dominance of manual instruments, the middle era with the improvement of instruments and astronomical table systems, the modern era with the entry of optical and mechanical instruments, and the digital era with the presence of computer software and Android-based applications. This study concludes that although the instrument of falak has undergone a significant transformation, practical knowledge of classical instruments is diminishing. Therefore, efforts are needed to revitalize and integrate classical instruments into contemporary falak education, so that the intellectual heritage of Islam is not only a historical artefact but also a relevant educational means in the digital era.

I. Introduction

Although classical astronomical instruments such as astrolabs, rubu' mujayyab, and mizwala played an important role in the development of astronomy, knowledge of these instruments was declining among the younger generation of Muslims. Many astronomy students are more familiar with digital applications and modern devices, such as telescopes and GPS, than with understanding the working principles of classical instruments [1]. As a result, a knowledge gap exists between the Islamic scientific heritage of the past and the technology used today. In fact, classical instruments are not only technical tools, but also representations of the scientific methodology and creativity of Muslim scientists who contribute to global science [2].

Astronomy is one of the branches of science that has undergone rapid development in Islamic civilization since the Middle Ages. This science is not only related to astronomical phenomena but also has practical implications for Muslims, such as determining the direction of the qibla, the time of prayer, and the beginning of the month of Kamariah [3]. The development of astronomy is closely tied to the use of astronomical instruments designed to aid in observing and calculating the positions of celestial bodies. These instruments serve as tangible evidence of the Islamic scientific heritage, affirming the significant contributions of Muslim scientists to global scientific civilization [2].

Since the classical era, Muslim scientists have designed and used instruments such as astrolabs, rubu' mujayyab, and mizwala for falak. Astrolabs, for example, are not only used to determine the height of the Sun or stars, but are also used in navigation and timing [4]. Rubu' mujayyab serves as a sine quadrant, allowing for simple trigonometry calculations in astronomy, while mizwala is used as a sundial to determine the beginning of prayer time [5]. These instruments demonstrate how astronomy was practised with an empirical approach, accompanied by sophisticated technical devices of its time.

Over time, the development of the falak instrument did not stop at the classical civilization of Islam. In the modern era, there has been a shift from manual instruments to optical and mechanical-based instruments, such as telescopes and theodolites. The development marked the entry of European technology into the Islamic world's philosophical tradition [6]. In the contemporary era, astronomical instruments have continued to evolve with the advent of digital devices and astronomy software, such as Stellarium, Accurate Times, and mobile applications for Android. This change shows the transformation of the astronomical instrument from a manual observation tool to a more practical and precise digital system [7].

The study of the evolution of the astronomical instrument is important for two main reasons. First, it highlights the continuity between the classical heritage of Islam and the development of modern technology, thereby fostering historical awareness among Muslims of the contributions of previous scientists. Second, he opens up opportunities for integration between classical and digital instruments in contemporary astronomy education, especially in Islamic universities and Islamic boarding schools. Thus, this study focuses on reviewing the development of astronomical instruments from the classical era to the digital era through a literature review sourced from historical Islamic science literature and contemporary publications on Islamic astronomy [8].

In the modern era, the development of astronomical instruments focuses more on digitalization aspects, such as computer-based hisab applications or astronomy software (Rausi, 2019). However, the lack of integration efforts between classical instruments and digital technology means that traditional instruments often become museum collections or historical reconstruction objects, with limited educational use [9]. This problem is becoming increasingly complex due to the lack of falak literacy in the general public, which leads to classical instruments being considered obsolete and no longer relevant to contemporary needs.

Thus, the main problems discussed in this study are: (1) the reduced understanding of classical astronomical instruments in Islamic science education and literacy, and (2) the challenges of integration and development of astronomical instruments in the modern era dominated by digital technology. This literature review aims to provide a historical overview and a critical perspective on the importance of linking classical heritage with contemporary developments in astronomy education and research.

II. Method

This research employs the library research method, which involves studying, reviewing, and analyzing various literature relevant to the topic of the evolution of astronomical instruments. The primary data sources comprise classic books on Islamic astronomical instruments, modern scientific works on the history of science, and contemporary journal articles that discuss the development of astronomical instruments from antiquity to the digital era. Data was collected through browsing scientific databases such as Google Scholar, JSTOR, and astronomy journal portals in Indonesia. Data analysis was conducted using a descriptive-qualitative approach, where each literature review was examined to identify the role, function, and transformation of the astronomical instrument over time. Furthermore, the findings are grouped into several development periods, namely the classical, medieval, modern, and digital eras, allowing for historical continuity to be observed. The main focus of the analysis is not only on the technical description of the instrument, but also on its epistemological value, educational relevance, and the challenges of integrating classical instruments into the contemporary astronomy context.

With this approach, the research does not intend to generate new empirical findings through field observations, but rather to develop a comprehensive understanding of the evolution of astronomical instruments based on the existing literature track record. This literature review approach was chosen because it is relevant to re-examine the intellectual heritage of Islam, as well as to review how the development of digital technology affects the sustainability of astronomical instruments in modern education and research.

III. Results and Discussion

This literature review demonstrates that the evolution of astronomical instruments does not occur statically, but rather through a gradual process that can be divided into four main phases: the classical, medieval, modern, and digital eras. Each phase of this development represents the response of Muslims to the needs of the times, both in the realm of worship and the development of science. In the classical era, astronomical instruments emerged from the creativity of Muslim scientists, who adapted Greek, Indian, and Persian knowledge to develop more practical devices [10]. In the medieval era, the instrument underwent improvements alongside the establishment of a large observatory that became a centre for Islamic astronomical research. Entering the modern era, the development of astronomical instruments was influenced by optical and mechanical technologies from the West, which introduced telescopes and high-precision measurement instruments. Meanwhile, in the digital era, the transformation of astronomical instruments is being accelerated by the presence of computers, satellites, and mobile application technology, making astronomy more accessible to the wider community. Thus, the evolutionary journey of the astronomical instrument not only reflects the change in the physical form of the instrument, but also reflects the change in the scientific paradigm from manual and empirical to mechanical and digital.

In the classical era (8th to 13th centuries AD), Muslim scientists developed various astronomical instruments that not only served as observational aids but also as devices for astronomical calculations, making them applicable to the daily lives of Muslims. Among the most prominent instruments are the astrolab, the rubu' mujayyab, and the mizwala [11]. Astrolabes are widely used to determine the height of the Sun and stars [12], calculate prayer times, measure the direction of the qibla [13], and assist in maritime navigation, making them one of the most important multifunctional instruments in the history of Islamic science [4].

Figure 1. Astrolabe reconstructed from the 8th century

Meanwhile, the rubu' mujayyab evolved as an instrument based on simple trigonometric principles, making it easier to calculate the positions of celestial bodies and apply the lunar calendar. A sundial, also known as a mizwala, is used practically to determine the beginning of prayer time by utilizing the length and direction of the shadow cast by an object [14]. More than just technical tools, the astronomical instruments of the classical period also reflect the ability of Muslim scientists to integrate the needs of worship with the development of science. This achievement not only demonstrates originality and creativity but also affirms the role of Islamic science as a bridge between the Greek astronomical heritage and the innovations that later became the basis for the development of instruments in the medieval era. Thus, the classical falak instrument serves as a symbol of the progress of Islamic civilization, both in scientific and religious aspects, whose influence can still be felt in the modern era.

Entering the Middle Ages (14th to 17th centuries AD), the use of astronomical instruments grew rapidly, along with the establishment of large observatories such as Maragha in Persia, led by Nasir al-Din al-Tusi, and Samarkand in Central Asia, under the care of Ulugh Beg [15].

Figure 2. Mragha Observatory

These observatories serve as centres for astronomical research, allowing scientists to develop instruments on a larger scale with a higher level of precision than in previous eras. Classical instruments, such as astrolabes [16] and rubu' mujayyab [17], were refined in both design and measurement methods, while new instruments, like the giant wall quadrant, were used to observe the trajectories of the Sun and stars with greater accuracy. In addition, in this period, various astronomical tables (zij) were also created based on the results of systematic observations, including Zij-i Ilkhani from Maragha and Zij-i Ulugh Beg from

Samarkand, which served to support the operation of the instrument as well as a reference for astronomical calculations in the Islamic world and Europe [18]. It makes the study of astronomy more systematic and structured, as observation instruments are now integrated with standardized mathematical methods. Thus, the medieval period can be seen as the heyday of astronomical instruments, which shows the ability of Muslim scientists to combine technological innovations in instruments with the development of astronomical theory and calculations.

In the modern era (18th to early 20th century), the development of astronomical instruments was significantly influenced by advancements in optical and mechanical technology from Europe, which entered the Islamic world through trade, colonialism, and academic exchanges [2].

Figure 3. Telescope from the 18th century

Telescopes began to be widely introduced and replaced some of the functions of traditional instruments in the observation of celestial bodies. With the ability to magnify images and improve the accuracy of observations, telescopes enable more precise astronomical observations than classical instruments such as astrolabs or rubu' mujayyab [19]. In addition, directional measurement instruments, such as theodolites, began to be used to determine the direction of the qibla, providing much more precise results compared to the use of mizwala or shadow-based instruments [6]. This transformation marked a methodological shift in the Islamic philosophy tradition, from a simple geometry-based manual system to a high-precision measurement system that utilized mechanical technology. However, the adaptation also had consequences: the use of classical instruments was decreasing, both because of their limited accuracy and because they were no longer considered relevant in the context of modern science. Some classical instruments have survived only in the tradition of traditional education as a means of basic learning, or are preserved as historical artefacts that illustrate the intellectual heritage of Islamic civilization. Thus, the modern era can be seen as an important transitional period, during which Islamic astronomy began to be closely connected to the development of global science, while simultaneously facing the challenge of maintaining the continuity of the classical intellectual tradition.

In the digital era (20th to 21st centuries), the development of astronomical instruments experienced a significant leap, accompanied by the emergence of computers, satellites, and digital-based software technology [20]. Traditional instruments that were once used manually are now largely replaced by astronomical applications that can be accessed through computers and smartphones. Software such as Stellarium, SkySafari, and Google Sky Map allow users to simulate the sky in real-time [21].

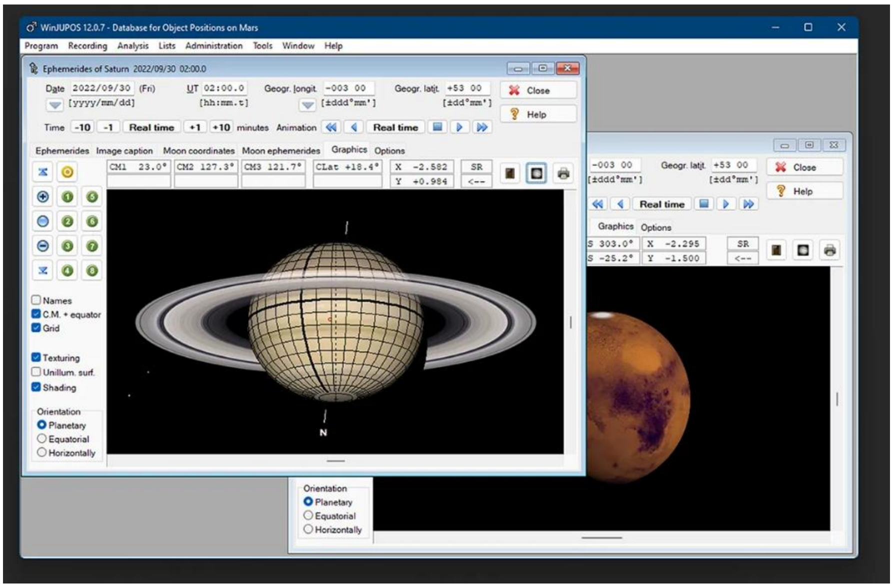

Figure 4. Modern Astronomy Software

In contrast, satellite data, such as the Visible Infrared Imaging Radiometer Suite (VIIRS) and the Global Positioning System (GPS), are used to map the direction of the qibla, determine prayer times, and conduct research on light pollution [22]. In addition, modern instruments such as digital telescopes, CCD cameras [23], and portable spectrometers [24] have made it easier to observe celestial bodies with a level of precision far surpassing that of previous eras. This transformation not only makes it easier for academics but also opens up wider access for the general public to learn astronomy practically. However, this phenomenon also poses a new challenge: the declining interest in understanding the working principles of classical instruments, as the younger generation tends to rely more on instant digital applications. Thus, the digital era can be seen as a phase of full modernization of astronomical instruments, where digital technology makes astronomy more inclusive and applicable, but also has the potential to break the chain of historical knowledge if it is not balanced with the preservation of classical instruments [25].

In general, the results of this study indicate a continuity between classical and modern falak instruments. Classical instruments laid the foundation for the development of optical and digital instruments. However, the biggest challenge faced today is how to bridge the understanding between classical instruments and contemporary technology, so that the scientific heritage of Islam is not just a historical object, but can be integrated into the modern astronomical education system.

IV. Conclusion

This literature review confirms that the evolution of astronomical instruments is clear evidence of the dynamics of Islamic science that are adaptive to the development of the times. Classical instruments such as astrolabs, rubu' mujayyab, and mizwala play a crucial role in facilitating the observation of the sky while meeting the practical needs of Muslims in determining the direction of the qibla, prayer times, and the beginning of the month of kamariah. In the Middle Ages, the instrument was perfected and combined with the astronomical table system, marking the pinnacle of the Islamic falak tradition's glory. Entering the modern era, optical and mechanical instruments from Europe, such as telescopes and theodolites, began to replace some of the functions of classical instruments. In the digital era, the transformation of astronomical instruments continued with the advent of computer software and Android-based applications, further facilitating people's accessibility.

However, this study also highlights the problem of a decreasing practical knowledge of classical astronomical instruments among academics and the public. This condition has the potential to result in a disconnection between the intellectual heritage of Islam and its application in the contemporary context. Therefore, efforts are needed to revitalize classical instruments by integrating them with modern technology, especially in the fields of astronomy education and research. Thus, classical heritage is not only positioned as a historical artefact, but can also serve as an educational medium that enriches conceptual and methodological understanding in astronomy in the digital age.

References

[1] Mursyid Fikri dan Baharuddin, “TRANSFORMASI PEMBELAJARAN ILMU FALAK dI ERA INDUSTRI (Application and Inspiring Learning Methods),” *Bidayah Stud. Ilmu-Ilmu Keislam.*, vol. 12, no. 2, pp. 180–191, 2022, doi: 10.47498/bidayah.v12i2.671.

[2] G. Saliba, *Islamic Science and the Making of the European Renaissance*. Massachusetts: MIT Press, 2007.

[3] M. Qorib, Zailani, Radiman, Amrizal, and A. J. R. Butar-Butar, “Peran dan Kontribusi OIF UMSU Dalam Pengenalan Ilmu Falak di Sumatera Utara,” *J. Pendidik. Islam*, vol. 10, no. November, p. 139, 2019, doi: https://doi.org/10.22236/jpi.v10i2.3735.

[4] H. C. King, *The History of Telescopes*. New York, 1997.

[5] U. N. Hanifa, “Keakurasian penggunaan Mizwala Qibla Finder dan Theodolit Sebagai Alat Ukur Dalam Menentukan Nilai Sudut Arah Kiblat,” UIN Sunan Gunung Djati, Bandung, 2019. Accessed: Apr. 22, 2022. [Online]. Available: http://digilib.uinsgd.ac.id/26873/

[6] S. H. Nasr, *Islamic Science: An Illustrated Study*. Westerham: Kazi Publications, 1995.

[7] N. A. Awwalany, S. Chotban, and S. Khalik, “Peluang dan tantangan ilmu falak di

indonesia era digital," *Hisabuna*, vol. 4, no. 3, pp. 123–146, 2023.

[8] S. T. Qulub and A. Munif, "Peran Teknologi Digital dalam Mengembangkan Ilmu Falak dalam Peradaban Islam," *ICONTIES (International Conf. Islam. Civiliz. Humanit.*, pp. 557–565, 2023.

[9] D. A. King, *World-Maps for Finding the Direction and Distance to Mecca: Innovation and Tradition in Islamic Science*. Brill, 1999.

[10] E. Gourtsoyannis, "Hipparchus vs. Ptolemy and the Antikythera Mechanism: Pin-Slot device models lunar motions," *Adv. Sp. Res.*, vol. 46, no. 4, 2010, doi: 10.1016/j.asr.2009.08.030.

[11] A. Budiwati, M. W. Firdaus, and G. C. Raharjo, "Integration Method for Measuring Qibla Direction (Comparative Analysis of Google Earth and Mizwala)," *Indones. J. Interdiscip. Islam. Stud.*, vol. 5, no. 3, pp. 147–164, 2022, doi: 10.20885/ijiis.vol.5.iss3.art2.

[12] M. H. Safiai, M. Z. A. H. Ashari, E. A. Jamsari, I. A. Ibrahim, and N. C. Noh, "Astrolabe alternative learning based on software and interactive application," *Int. J. Adv. Appl. Sci.*, vol. 8, no. 6, 2021, doi: 10.21833/ijaas.2021.06.012.

[13] H. R. Setiawan, A. J. Rakhmadi, M. Hidayat, A. Y. Raisal, and H. Putraga, "Perbandingan Perhitungan Waktu Shalat Menggunakan Astrolabe RHI dan Accurate Times," *Al-Ahkam J. Ilmu Syari'ah dan Huk.*, vol. 6, no. 2, 2021, doi: 10.22515/alahkam.v6i2.3416.

[14] N. K. Nizam, M. S. A. Mohd Nawawi, S. Man, R. Abdul Wahab, and N. Ahmad Zaki, "Pendekatan Tempatan dalam Mendepani Isu -Isu Penentuan Waktu Solat," *J. Fiqh*, vol. 16, 2019, doi: 10.22452/fiqh.sp2019no1.6.

[15] S. Rambe and A. I. Sinaga, "Peran Observatorium Ilmu Falak Umsu Dalam Pendidikan Islam di Kota Medan 2019," *Tesis UIN Sumatera Utara*, vol. 3, no. 217, 2019.

[16] F. Rausi, "Astrolabe; Instrumen Astronomi Klasik Dan Kontribusinya Dalam Hisab Rukyat," *Elfalaky*, vol. 3, no. 2, pp. 120–137, 2019, doi: 10.24252/ifk.v3i2.14149.

[17] M. Hidayat, *Pengembangan Media Rubu' Al-Mujayyab*. Yogyakarta: Bildung, 2020.

[18] B. Van Dalen and M. Yano, "Islamic Astronomy in China: Two New Sources for the

Huihui Li ('Islamic Calendar')," *Highlights Astron.*, vol. 11, no. 2, 1998, doi: 10.1017/s1539299600018499.

[19] V. Ilardi, "Renaissance vision from spectacles to telescopes," in *Frontiers in Optics 2004/Laser Science XXII/Diffractive Optics and Micro-Optics/Optical Fabrication and Testing*, Washington, D.C.: OSA, 2004, p. FWW7. doi: 10.1364/FIO.2004.FWW7.

[20] D. A. Sujati, R. R. Isnanto, and ..., "Pengembangan aplikasi multimedia untuk pembelajaran satelit astronomi nasa dengan teknologi augmented reality berbasis android," 2016, *pdfs.semanticscholar.org*.

[21] G. Zotti, S. M. Hoffmann, A. Wolf, F. Chéreau, and G. Chéreau, "The Simulated Sky: Stellarium for Cultural Astronomy Research," *J. Skyscape Archaeol.*, vol. 6, no. 2, pp. 221–258, 2021, doi: 10.1558/jsa.17822.

[22] D. Pilendia, "Stellarium sebagai Media Pembelajaran Fenomena Astronomi: Kajian Literatur," *J. Ilm. Wahana Pendidik.*, vol. 8, no. 1, pp. 525–532, 2022, doi: 10.5281/zenodo.5899734.

[23] M. C. Weisskopf, B. Brinkman, C. Canizares, G. Garmire, S. Murray, and L. P. Van Speybroeck, " An Overview of the Performance and Scientific Results from the Chandra X-Ray Observatory ," *Publ. Astron. Soc. Pacific*, vol. 114, no. 791, pp. 1–24, 2002, doi: 10.1086/338108.

[24] J. P. Gardner *et al.*, "The James Webb space telescope," *Space Sci. Rev.*, vol. 123, no. 4, pp. 485–606, 2006, doi: 10.1007/s11214-006-8315-7.

[25] A. Akrim, "Nilai-Nilai Pendidikan Islam dalam Observatorium," *Al-Marshad J. Astron. Islam dan Ilmu-Ilmu Berkaitan*, vol. 6, no. 1, p. 4, 2020, doi: http://dx.doi.org/10.30596%2Fjam.v6i1.5224.