IOSR Journal of Humanities and Social Science (IOSR-JHSS)
Volume 31, Issue 10, Series 3 (October, 2026) 62-74
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Ibn Mājid's *Kitāb Al-Fawā'id* and The Concepts of 'Trial and Error' And 'Methodological Doubt' I: The Data

Andreas Eckart* and Mesut Idriz**

Abstract:
The well-established concepts of 'trial and error' and 'methodological doubt' can be compared to concepts found in the book of navigation "Kitāb al-Fawā'id" [The book of benefits] by the great Arabian navigator and writer Aḥmad ibn Mājid. While these concepts were developed in the 19th century by Conwy Lloyd Morgan and in the 17th century by René Descartes, respectively, we show that comparable concepts were developed and applied more than 200 years earlier by Ibn Mājid. We present textual evidence from his work highlighting how the observer's psychological and physical characteristics are integral to the scientific process of accurate measurement, calculation, and the reliable transmission of knowledge. Specifically, we provide an exhaustive (complete) catalogue of the sections within the Kitāb al-Fawā'id where Ibn Mājid details his protocols for data collection, evaluation of inherited knowledge, and professional interactions with fellow navigators and mariners. This catalogue is required for later analysis.

Keywords: *Ibn Mājid, Ibn al-Haytham, René Descartes, Conwy Morgan, Arabic astronomy, time keeping and navigation*

Date of Submission: 15-10-2026 Date of Acceptance: 23-10-2026

I. INTRODUCTION

When delving into the history of early astronomy, timekeeping or navigation, we are often fascinated by the impressive observational results,[1] intricate celestial mechanics computations, and innovative instrumentation.[2] However, the pivotal role of the observer frequently remains in the shadows. The observer's psychological and physical properties played a crucial part in shaping the scientific process, influencing the accuracy and reliability of measurements and calculations. Various factors, including reaction time, visual acuity, and cognitive biases, could compromise the quality of observations, while physical conditions such as fatigue, stress, or environmental factors could significantly impact the observer's performance.

Moreover, the acquired knowledge had to be meticulously evaluated, documented, and communicated to colleagues, whether it involved building on existing knowledge or integrating novel discoveries. The transfer of knowledge might have adhered to protocols, which warrant exploration. This contribution seeks to illuminate the often-overlooked human dimension in early observational sciences, with a focus on the works of the famous

* Prof. Dr. Andreas Eckart (eckart@ph1.uni-koeln.de), a native German, is a full professor emeritus for experimental physics at the University of Cologne, Germany, and external member of the Max-Planck-Institute for Radioastronomy (MPIfR) and scientific member of the Max-Planck-Society (MPG). He received his doctoral degree from the Westfälische Wilhelms-University Münster (WWU) and habilitated at the Ludwig Maximilian University of Munich (LMU).

** Prof. Dr. Mesut Idriz (m.idriz@sharjah.ac.ae), a native of North Macedonia, received his graduate and doctoral degrees from the International Institute of Islamic Thought and Civilization (ISTAC), International Islamic University Malaysia (IIUM). Currently he is Co-Chairholder of UNESCO Chair on Science Diplomacy and Scientific Heritage, Professor of Comparative History of Civilizations and Director of the Sharjah International Foundation for the History of Arab and Muslim Sciences (SIFHAMS), University of Sharjah, United Arab Emirates.

1 George Saliba, "The Role of the *Almagest* Commentaries in Medieval Arabic Astronomy: A Preliminary Survey of Ṭūsī's Redaction of Ptolemy's *Almagest*," in *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam* (New York University Press, 1994).

2 Tofigh Heidarzadeh, "Islamic Astronomical Instruments and Observatories," in *Handbook of Archaeoastronomy and Ethnoastronomy*, ed. J. McKim Malville and Clive L. N. Ruggles (Springer, 2015), https://doi.org/10.1007/978-1-4614-6141-8_203.

Arabic navigator Ibn Mājid[3] (ca. 1432–1500), who skilfully merged astronomical knowledge with navigational expertise. Furthermore, we will draw on the writings of the polymath Ibn al-Haytham, offering valuable perspectives on the observer's role in scientific enquiry.

In addition to the knowledge and techniques passed down from ancestors, the exploration and development of new knowledge and methods is crucial. The latter is often influenced by heuristic problem-solving methods, in which possible solutions are repeatedly tested until a suitable solution is found. This often involves accepting (and using) the possibility of errors in the process of generating or transmitting of information or procedures. This approach is often referred to as "trial and error."[4]

Cartesian doubt, a concept developed by René Descartes[5] (1596–1650), is a form of methodological scepticism. This approach is also referred to as Cartesian scepticism or methodical doubt, among other terms. Cartesian doubt is a deliberate and structured process of doubting one's beliefs to establish a foundation for knowledge. Descartes' method has been seen as a precursor to the modern scientific method.[6] While scholars like Mohammad Alwahaib provide robust philosophical comparisons of methodical doubt between Al-Ghazālī and Descartes,[7] our study shifts focus to a practical domain. By contrasting Descartes with Ibn Mājid, we explore the intersection of philosophical methodical doubt and professional, real-world scepticism within a navigational context.

In the present contribution, we present the data for our claim that the concepts of "trial and repetition" (as we will see an early version of "trial and error") as well as the concept of methodological scepticism put forward by Ibn Mājid are close to the more modern well-established concepts. The present work is characterised by its commitment to high systematic rigour. Specifically, this contribution provides an exhaustive catalogue of the sections within the *Kitāb al-Fawā'id* where Ibn Mājid details his protocols for data collection, evaluation of inherited knowledge, and professional interactions with fellow navigators and mariners.

A detailed comparison and discussion of the "trial and repetition" and "trial and error" concepts is given in our adjacent analysis paper.[8] While the historical ideas by Ibn Mājid lack the rigour or terminology of the modern ones, they contain the "seed" or essential logic that eventually evolved into the modern version.

In the transliterations, we use *j* and *īy*, instead of *ǧ* and *iyy*, as well as *sh*, instead of š. All translations were made or revised by the authors.

The paper is organised in the following way: In section 2, we present Ibn Mājid and the sources for this work. Section 3 deals with the investigation of Ibn Mājid's *Kitāb al-Fawā'id*. Here, we discuss several quotations from the text and comment on them. In section 3.1, we discuss the properties of an ideal navigator as seen by Ibn Mājid followed by Ibn Mājid's statements on the value of information in section 3.2. In 3.3, we learn about experience and learning by doing. Here, we highlight Ibn Mājid mentioning the concept of "trial and repetition," which is similar to the concept of "trial and error," as we will see in the discussion. In section 3.4, Ibn Mājid explains how to take proper nautical measurements and in section 3.5 he comments on the necessity of the skill of calculation. Section 3.6 then allows us to gain insight into Ibn Mājid's relation to the crew and passengers and the advisability to keep control over them. In section 3.7, we deal with his complaints about the absence of proper latitude measurements even in maritime areas well known to the Arabs. A summary and outlook are given in section 4, followed by acknowledgements and an appendix. We present a detailed discussion of the information as extracted from Ibn Mājid's *Kitāb al-Fawā'id* in our adjoining paper.

II. IBN MĀJID AND THE SOURCES FOR OUR WORK

Aḥmad ibn Mājid ibn Muḥammad al-Saʿdī al-Jaddī al-Najdī, commonly referred to as Ibn Mājid, stands out as one of the most celebrated and renowned Arabian navigators and cartographers of ancient times. Born in ca.

---

3 Aḥmad ibn Mājid is a famous navigator who sailed the Indian Ocean and wrote several books on seafaring. Further details about him and his work can be found in the next section.

4 Robert Jackson et al., "Trial-and-Error Solving of a Confinement Problem by a Jumping Spider, Portia fimbriata," *Behaviour* 138, no. 10 (2001), https://doi.org/10.1163/15685390152822184.

5 René Descartes is a French philosopher, scientist and mathematician. He is widely considered an essential figure in the emergence of modern science and philosophy.

6 René Descartes, *Discourse on the Method*, trans. Donald A. Cress (Hackett Publishing Company, 1998). See also Abū Ḥāmid al-Ġazālī, *Deliverance from Error: Five Key Texts Including his Spiritual Autobiography, al-Munqidh min al-Dalal*, trans. Richard J. McCarthy (Fons Vitae, 1999); Abū Ḥāmid al-Ġazālī, *The Faith and Practice of Al-Ghazali*, trans. W. Montgomery Watt (George Allen & Unwin, 1953).

7 Mohammad Alwahaib, "Al-Ghazālī and Descartes from Doubt to Certainty: A Phenomenological Approach," *Discusiones Filosóficas* 18, no. 31 (2017), https://doi.org/10.17151/difil.2017.18.31.2.

8 Andreas Eckart and Mesut Idriz, "Ibn Mājid's Kitāb al-Fawā'id and the Concepts of 'Trial and Error' and 'Methodological Doubt' II: Analysis," *adjacent analysis paper.*

1421 into a seafaring family in the city of Sūr, in north-eastern Oman on the coast of the Gulf of Oman, Ibn Mājid's life was intricately tied to the sea. It is estimated he passed away around 1500.[9]

Ibn Mājid was a prolific writer, having produced approximately 40 works that encompassed poetry and prose. His literary contributions extended to several books focused on marine topics, with emphasis on the Persian Gulf and Indian Ocean. These writings not only showcased his expertise in navigation and cartography but were also invaluable resources for those traversing the vast expanse of the sea.

Hailing from a family deeply rooted in seafaring traditions in Oman, Ibn Mājid's writings played a pivotal role in facilitating navigation and exploration. His books provided crucial information that enabled residents of the Persian Gulf to embark on journeys to the coasts of India, East Africa, and other destinations. Ibn Mājid's contributions to the field of navigation and cartography are immeasurable. His works not only reflected his profound understanding of the sea but also paved the way for future generations of navigators and explorers. Among his notable works is the "*Kitāb al-Fawā'id fī Uṣūli 'Ilmi al-Baḥr wa-al-Qawā'id*," literally translated as "the book of benefits on the science of the sea and the rules [of navigation]."

The *Kitāb al-Fawā'id* stands as testament to his expertise, offering insights into the science of navigation and the rules that governed maritime travel during his era. The book is organised in several *Fawa'id* from the first to the twelfth *Fa'ida*. It was translated and commented on by Gerald R. Tibbetts.[10] As Tibbetts explains in his book, his translation is based on the manuscripts MS2292 of the Bibliothèque Nationale de France (BnF) and #2559 of the Ẓāhiriyya Library in Damascus.[11] The latter was discovered in 1921. The Arabic manuscript MS2292 was acquired by the BnF on 3 May 1860 from Sulayman al-Hara'iri (1824–1875), who was employed at the French consulate in Tunis then as an Arabic tutor at the École des Langues Orientales Vivantes.[12] For our work, we had access to the 1925 copy of the Damascus version. It is now available in digital form as SM-53[13] at the Library of Congress in Washington. It is described in detail in a paper by Marina Tolmacheva.[14] From Tibbetts' and Tolmacheva's work, we concluded there are no major differences between manuscripts MS2292 and #2559.

For this paper, we analysed all passages from Ibn Mājid's work, *Kitāb al-Fawā'id*, that directly relate to the transfer or creation of navigational or astronomical knowledge. Where quoted passages are marked with "quotation," we have taken them directly from Tibbetts' work. In some cases, we considered a translation closer to the Arabic text more appropriate. In these cases, the passages are marked with "translation." In both cases, the English text of the quoted passages was compared in detail with the Arabic text. In copying the Arabic text, in our quotations and translations, we have tried to stay as close to the Damascus copy SM-53 as possible.

In addition, our research draws on classical Arabic texts from the 7th to the 15th centuries and used *al-Maktaba al-Shāmila*[15] for the investigation. This already lead to a thorough investigation of the use and description of the Milky Way in early Arabic society, including works by scholars Ibn Raḥīq,[16] Ibn al-Haytham,[17] Ibn Mājid[18] and others. The results of this investigation are summarised in an article by Eckart and Idriz.[19]

---

9 See Thomas Glick, Steven J. Livesey, and Faith Wallis, eds., "Ibn Mājid, Ahmad," in *Medieval Science, Technology, and Medicine: An Encyclopedia* (Routledge, 2005), 252, https://doi.org/10.4324/9781315165127.

10 Gerald R. Tibbetts, *Arab Navigation in the Indian Ocean Before the Coming of the Portuguese*, Oriental Translation Fund, vol. 42 (Royal Asiatic Society of Great Britain and Ireland, 1971; repr., 1981).

11 Ibid., 25.

12 Personal communication on 15. Sept. 2025 with M. Khalid Chakor Alami, Chargé des manuscrits arabes et persans, BnF, Département des Manuscrits, 58, rue de Richelieu 75084 Paris Cedex 02.

13 Aḥmad ibn Mājid, *Kitāb al-Fawā'id fī uṣūl 'ilm al-baḥr wa-al-qawā'id* [The book of Benefits on the Principles of Navigation and Nautical Rules], 1925 (copy of Damascus version), SM-53, Near East Section, Library of Congress, Washington, DC.

14 Marina Tolmacheva, "An Unknown Manuscript of the *Kitāb al-Fawāʾid*," *Journal of the American Oriental Society* 114, no. 2 (1994), https://doi.org/10.2307/605131.

15 Al-Maktaba al-Shāmila (Comprehensive Library) is a comprehensive open source collection of Arabic texts from early Islamic history until today, available at http://al-maktaba.org/. After an initial electronic search, we verified all references in copies of the printed texts.

16 Andreas Eckart, "Ibn Raḥīq's Text on the Milky Way: Perception of the Milky Way in the Early Islamic Society," *Arabic Sciences and Philosophy* 29, no. 2 (2019), https://doi.org/10.1017/S0957423919000055.

17 Andreas Eckart, "The Early Great Debate: A Comment on Ibn al-Haytham's Work on the Location of the Milky Way with Respect to the Earth," *Arabic Sciences and Philosophy* 28, no. 1 (2018), https://doi.org/10.1017/S0957423917000078.

III. INVESTIGATING IBN MĀJID'S *KITĀB AL-FAWĀ'ID*

In the following, we first highlight the properties of a pilot and navigator (we use these terms in this work interchangeably). Then we find out how he processed information, i.e., how he passed information to the pilot and generated new information, which he then possibly passed to his colleagues. This is followed by an analysis and critique of this process. In the appendix we list all text sections we used from the *Kitāb al-Fawā'id*.

3.1 Properties of an Ideal Navigator following Ibn Mājid

The navigator seems to have been a professional who need not to possess anything beyond his nautical skill. It is most likely that the *nākhodā* (ناخُوذَاة), i.e. the shipmaster who may also be the shipowner, made a contract with a *mu'allim* (مُعَلِّم), i.e. navigator, for a voyage.[20] These men were organised in a guild and class (fraternity) of pilots that were basically enslaved by their duties. This means their lives and daily routines were completely taken up by their duties and responsibilities as pilots.

As we will see, pilots had special characteristics and duties that clearly distinguished them from ordinary people or sailors. They bore enormous responsibility for the transported goods, ship, crew, and passengers. Since they were essential to the success of each voyage and usually contracted out, they probably spent most of their lives on the ship, in port and at sea – except in bad weather or out of season time, when, for example, the required winds were not blowing. Astronomers and timekeepers probably had a similar fate. They used their expertise to measure time and determine the location of places and, of course, the *qibla* (direction of prayer). They also recorded celestial phenomena, as these were important for understanding the world and sometimes for political decisions. In a few places, Ibn Mājid outlines the general properties of a pilot. From the second *Fa'ida*:

وينبغي للمعلم ان يعرف الصبر من التواني ويفرق بين العجلة والحرك عارفا عالما بالأشيأ عزاما فتاكا لين في قوله عادلا لا يظلم احدا لاحد مقيم على الطاعه لربه متق لله تعالي لا يغصب التجار على حقوف الا على شئ وقع عليه لقول اوجرت به العدة كثير الاحتمال عالى الهمه صبارا مقبولا بين الناس لا يسعى فيما لا يصلح له اديبًا لبيبًا
والا فليس هو معلم بالقاعدة

Translation: The navigator should know patience from laziness and differentiate between haste and movement. He should be knowledgeable and aware of things, determined, assertive, gentle in his speech, just, not wronging anyone, committed to obedience to his Lord, fearing God Almighty, not usurping merchants' rights except for something he has committed to, based on a statement that has been prepared, very tolerant, high-spirited, patient, accepted among people, not striving for what he is not suited for, well-mannered and intelligent. Otherwise, he is not a navigator by the rule.[21]

What is described here is a balanced, self-assured personality. Someone who stands in the world and possesses enough knowledge to understand it sufficiently and navigate it intelligently. At the same time, his relationship with people is balanced and tolerant, so he is accepted by all, but also, under certain conditions, accepts and tolerates his fellow human beings. These conditions are characterised by a firm grounding in faith and a conscious renunciation of the exercise of power over his merchants and seafaring colleagues.

Only if a person complies with all these conditions and circumstances is he qualified for the position of navigator. This requires an extremely high degree of self-discipline, which clearly distinguishes the navigator from ordinary travellers and typical sailors.

There are three types of navigators:[22] All these requirements are not easy to fulfil, and even those who strive to become good navigators cannot always meet all of them. This results in a classification that essentially represents a level of perfection with respect to the requirements of an ideal navigator. Ibn Mājid highlights there are three types of pilots and discusses them in the Ninth *Fa'ida*.

The **first type** is the navigator who comes and goes, sometimes suavely and sometimes not, making good and erroneous decisions. This is the lowest form of navigator.

Here, the picture of the pilot is far from ideal. He is basically a normal sailor with some special responsibilities that he can live up to or not. Success contains an element of randomness or luck.

---

18 Andreas Eckart, "Use of the Galaxy as a Tool for Spatial and Temporal Orientation during the Early Islamic Period and up to the 15th Century," *Arabic Sciences and Philosophy* 31, no. 1 (2021), https://doi.org/10.1017/S0957423920000077.

19 Andreas Eckart and Mesut Idriz, "Knowledge of the Milky Way in the Arabic Cultural Region between the 8th and the 15th Centuries," *Australian Journal of Islamic Studies* 8, no. 3 (2023), https://doi.org/10.1017/S0957423920000077.

20 For more details, see Tibbetts, *Arab Navigation in the Indian Ocean*.

21 Ibn Mājid, *Kitāb al-Fawā'id*, Second Fa'ida, 16, line 4. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 77, line 24.

22 For more details, see Tibbetts, *Arab Navigation in the Indian Ocean*. Ibn Mājid, *Kitāb al-Fawā'id*, Ninth Fa'ida, 151, line 19. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 215, line 20.

The **second type** is the navigator who is well-known by people for his excellent knowledge, cleverness and skill in every place to which he travels. He collects experiences, but is not known after his death.
Here, the pilot is equipped with properties that make him special. He is calm, determined, knowledgeable, respected, clever and experienced.
The **third type** of navigator, who is the highest ranking of all, is well-known for his excellent knowledge and great attainments from whom none of the problems of the sea are hidden. He writes books that can be used during his life and after his death.

In addition to the above, the pilot is well known, respected, writes books to transmit his knowledge to his current and future colleagues, and remains well known even after his death. This description bears strong autobiographical content: Ibn Mājid clearly falls into this third category and he must have been aware of this. One could argue that he is indulging in arrogance and self-importance here. However, he writes this in a work intended as a textbook. He is aware of the complexity of a navigator's tasks from his extensive experience. Above all, he knows, to continue this profession successfully, a near-perfect transmission of knowledge across generations is essential. This is precisely what he attempts to convey to the reader, and thus to the student, through his description of the three classes of navigators.

Arguing with ignorance and stealing knowledge: The transfer and exchange of knowledge are essential in every field of work – and so it is in navigation. This process brings with it two things. First, a reinforcement and weighting of the transmitted knowledge. This echoes the concept of *isnad*,[23] in which information and quotations are evaluated according to the credibility of the source and person transmitting it. Second – and linked to the first fact – there is potential gain in reputation and honour, or even material gain. Knowledge can be reflected in improving the profitability of any type of business. If this happens in the public sphere, it leads to notoriety and possibly fame. Both facts can tempt people to see their advantage in dishonestly using or sharing information. This process is more serious when it is coupled with ignorance. If ignorance or lack of understanding the material being transmitted prevails, irreparable damage can result.
Despite the honour, there is also the danger of being misunderstood or even exploited as can be understood from the following:

ولم أر غير من يماري بجهله ويسرق العلم
ونزاحم في الجواب لا خفاء الصواب
فقت هذا البيت واشرت ببعض منه لمن يأتي بعدى

Translation: I have not seen anyone but those who argue with their ignorance and steal knowledge. We compete in [finding] the answer, not hiding the truth. I excelled at this verse and I have indicated some of it (the true facts) for those who come after me.[24]
He continues:
Quotation: The friend and knowing man will thank him (the 3rd type of navigator) and the envious and contrary man will blame him and the people envious of him - will steal from his works…Ignorant men use the tongue without restriction…leave abusive chatter to them…this will not harm you at all during your life or after your death, but it will increase your reward and honour because people only envy those who have excellent qualities, as one of the earlier writers put it in a poem:
If they envy me, I will not blame them,
before me many excellent people have been envied.[25]
Ibn Mājid finds himself at the mercy of this process of abuse or unwilling misconduct. In a sense, he capitulates, since this phenomenon cannot be influenced by him. Even a navigator or pilot with the best qualities is exposed to adversities. He must constantly defend himself, especially if his statements are misused or even stolen. Ibn Mājid, however, is firmly convinced that the righteous pilot will emerge stronger from this fight for truth and justice. He even believes these animosities will ultimately not harm his reputation even after his death. He is also aware that being a righteous navigator may not always be recognised by his fellow human beings and may even be envied.

3.2 The Value of Information

The determination and application of information as well as the success of correct behaviour corresponding to an ideal navigator is commented on by Ibn Mājid:

---

[23] In Islam, *isnād* (إسناد) refers to the chain of authorities who transmit a report (in religious context, the hadith) from the original source to the current compiler or reciter.

[24] Ibn Mājid, *Kitāb al-Fawā'id*, Fourth Fa'ida, 86, line 7. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 147, line 10.

[25] Ibn Mājid, *Kitāb al-Fawā'id*, Ninth Fa'ida, 152, line 5. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 215, line 30.

وتامل جميع الالات خصوصا فى السكّان فى كل حين وساعه وتامل بحس النبا المستقبل لا يغمك التعب الذى انت فيه فانه منسى ولا تنام الا بقدر ما يدفع عنك السنه السهر وعند ما ترقد لا تخلى المسكن وحده - وحارب النوم الحرب الكلى فان الحنير البقى وان طال الزمن به واشرأ خيث ما اودعت من نراد

Translation: Consider all instruments, especially the rudder, at all times and hours, and consider with a sense of future news. Do not be saddened by the fatigue you are in, for it is forgotten. Do not sleep except as much as will keep you from the sleepless nights. And when you lie down, do not leave the helmsman alone. Fight sleep with total warfare, for sleep is eternal, even if time is long. And it is more evil than what you have deposited of desires.[26]

In Tibbetts. we find the translation of this passage:

When you are tired do not let it get better of you, for it includes forgetfulness but do not sleep except the amount required of you by old age or the extent of your tiredness and when you sleep do not leave the helmsman alone The disrupter of sleep is the enemy of all men.[27]

Ibn Mājid encourages the reader and student to remain constantly vigilant. Constantly checking equipment allows for early detection of unforeseen events and the timely initiation of countermeasures. In particular, the navigator should not allow sleep to overwhelm them. Too little or too much sleep is harmful and does not contribute to the successful completion of any mission. Apparently, Ibn Mājid supports this statement with verses from an unnamed poet. However, here again the verse quoted by Tibbetts, "The disrupter of sleep is the enemy of all men," is more an interpretation of the statement given by Ibn Mājid according to the Damascus version of the text. One can say that, even today, the advice Ibn Mājid gives the reader remains true: be informed in a timely manner; live consciously; do not underestimate or overestimate your sleep; and take control and support your personality.

Even though Ibn Mājid gives precise instructions on how a navigator should behave in order to be successful and, above all, reliable and credible, he warns the reader against excessive expectations:

Quotation: If you fall short in the doing of any of this then you will only have yourself to blame. Your results should be better than those of anyone else who sails the sea and if you have done all I have suggested and come to grief, the blame is on me entirely living or dead. As for fate one can do nothing about this for it comes from God.[28]

Ibn Mājid seems almost cocky – probably to demonstrate and strengthen his powers of persuasion – for he might have meant: "If you follow my advice, you will succeed – I can guarantee it, and if you fail despite following the advice, it must be my fault." He adds, as a precaution, "The final element of uncertainty is fate." Here, too, Ibn Mājid is cautious, encouraging the reader to act as their best navigator would do, but also acknowledging that there is no guarantee of success and it ultimately depends on fate.

3.3 Experience and Learning by Doing

Ibn Mājid's primary concern is to gather and use experiences, test them, and pass them on successfully. This is particularly evident in the following statement (see also Figure 1 from the historical SM-53 text copy):

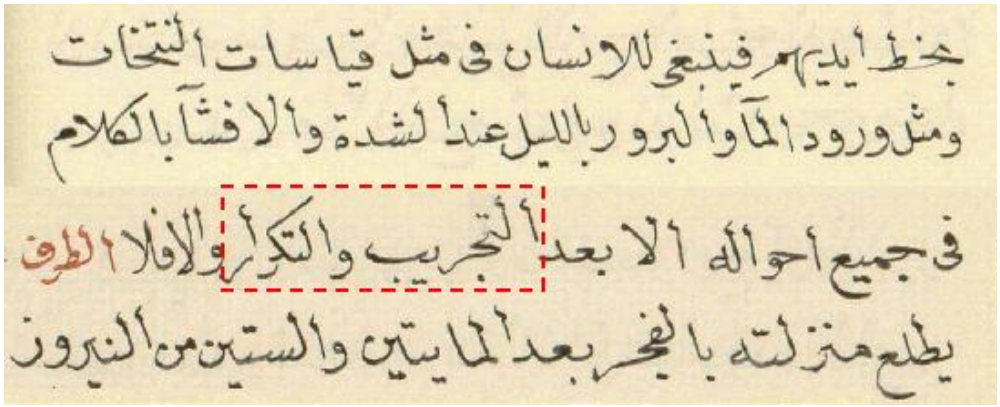


Figure 1: Excerpt from Ibn Mājid in the Third *Fa'ida*, 32, line 22; see also Tibbetts, *Arab Navigation in the Indian Ocean*, 94, line 8. This text section from the historical SM-53 copy in Washington explicitly

[26] Ibn Mājid, *Kitāb al-Fawā'id*, Eighth Fa'ida, 130, line 4. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 193, line 1.

[27] Ibn Mājid, *Kitāb al-Fawā'id*, Eighth Fa'ida, 130, line 6. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 193, line 7.

[28] Ibn Mājid, *Kitāb al-Fawā'id*, Eighth Fa'ida, 130, line 18. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 193, line 24.

mentions how Ibn Mājid expects traditional and newly obtained information to be transformed into verified knowledge, i.e., through 'trial and repetition,' (see text highlighted by the red dashed frame), which can be safely passed on to colleagues.

فينبغى للإنسان فى مثل قياسات النتخات ومثل ورود المأ والبرور بالليل عند
الشدة والا فشأ بالكلم فى جميع أحواله الا بعد التجريب والتكرار والا فلا الطرف يطلع منزلته

Translation: It is appropriate for a person in situations such as the measurement for landfall [characteristic smells] and the occurrence of [rising] water and coasts [lines] at night in times of distress. He should not comment in any case unless he can demonstrate a lot of experimentation (trials) and repetition. Otherwise he will not correspond to his position.[29]

This paragraph contains the core processes of information acquisition and processing: "…only after experimentation and repetition' or…only after trials and repetition."

… الا بعد التجريب والتكرار

Tibbetts translates التجريب as 'experience' (i.e., التجربة or خبرة) rather 'experimentations' or 'trials.'[30] The ideal navigator must therefore gain experience through trial and repetition and base his judgment primarily on this. However, Ibn Mājid emphasises that simply following this core principle is not enough. Trial and repetition must also be guided by implementation and applied action based on what has been learned. In particular, the navigator must not form a judgment about a fact or the implementation of an action unless he has experienced it and can substantiate it through his personal actions. In difficult situations, the navigator should take responsibility – but only speak up if there is a real reason to do so – judging this is based on multiple experiences.

3.4 How to take Proper Nautical Measurements

In addition to traditional information, the main source of data, especially for everyday life and keeping a course during seafaring, is measurement. Measurements must be precise, reliable, and above all, repeatable, so any measurement can be confirmed and reliably supplemented by further investigations. In the morning, determination of location plays an important role. While course and position can be reliably determined at night by determining stellar positions, the stars are not easily accessible during dawn because they are faint compared to the increasingly bright sky. Therefore, at the end of night and early in the morning, the navigator often wakes after a period of rest and has to take a measurement. For these measurements to produce reliable results that also stand up to verification, various criteria must be met, according to Ibn Mājid's experience. Therefore, he gives precise instructions on how to carry out the measurement:

وأعلم أن للقياسات عدد فهنها فهمها أذا قمت من النوم ينبغى أن تغسل
وجهيك وعينيك بمأ بارد وتجرد الجلس وتجعل النجم المقيوس عن النجم
الذى يلقى وجهك سبعة أخنان كالجاه والطاير

Translation: Know that for the measurements there are a number of things that need to be considered [by a navigator], so when you wake up from sleep, you should wash your face and eyes with cold water and relax your sitting position. Then put the measured star at a separation of seven rhumbs from the star that you are facing, like [between] the Pole Star and Altair.[31]

Here, seven rhumbs correspond to about 80 degrees[32] in today's angular measurements. Ibn Mājid then expands on the description of the measuring procedure:

والزحن من مفسدات القياس وفساد الجلسة والباشي الفاسد

Translation: The heat haze is one of the things that corrupt the measurement as well as anseating [position] and a corrupt *bāshi*.[33]

The latter two points refer to a poor sitting position during the measurement and an inaccurate determination of the *bāshi*. The *bāshi* (الباشي) is a variation of Polaris' (the northern polar star) altitude. This is explained in some depth in a later section. It was a fundamental measurement that helped determine the observer's geographical latitude. This measurement had to be performed precisely, otherwise there was a risk of losing the course and

---

29 Ibn Mājid, *Kitāb al-Fawā'id*, Third Fa'ida, 32, line 22. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 94, line 8.

30 The translation linked to 'experiment, test, trial, trial of a thing time after time' is clearly supported by the entries in Edward William Lane, *Arabic English Lexicon* (Williams and Norgate, 1867): prove by trial or experiment or experience, trial of a thing time after time, i.e. the experiment is dominating clearly.

31 Ibn Mājid, *Kitāb al-Fawā'id*, Seventh Fa'ida, 127, line 16. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 189, line 29.

32 Tibbetts, *Arab Navigation in the Indian Ocean*, 189, last but one line.

33 Ibn Mājid, *Kitāb al-Fawā'id*, Seventh Fa'ida, 128, line 2. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 190, line 10.

getting lost. This topic is apparently so important to Ibn Mājid that almost immediately after the above quotation, he provides a list of the various *bāshi* values and their names. This shows that this measurement had a fundamental value for seafaring at that time.

3.5 The Skill of Calculation

In addition to celestial measurements, the naval positions had to be calculated from direction, speed and travel time. This could be complex if speed and direction changed several times during the journey. Hence, the skill of calculating these quantities was required. Ibn Mājid criticised that these skills were often lacking:

Quotation: So we put this calculation before him but he was unable to solve it which showed his weakness at this. He said 'This which you have brought to me is not my sort of question', so I said to him 'Inform me about it and I will be responsible for what you say'. He replied 'Give me time', but I said, 'Delay will not help the one who puts the question, even if it will help the answer which you give to it.' I and all those present (and there were 22 there) knew that his answer was weak.[34]

It is interesting how this weakness was identified. Apparently not in a face-to-face interview, but in front of and with a group of people – possibly colleagues who were also navigators. Such a comparison allows the interview partners to present their arguments instead of avoiding the topic. Navigational skills and the ability to perform fundamental calculations are essential to ensure mission success. Any errors could jeopardise the fate of the crew and cargo being transported. Therefore, such a public reprimand would inevitably have influenced the awarding of contracts by land-based merchants.

3.6 Maintaining Control over Crew and Passengers

Mission success also depends on the behaviour of the crew and passengers. In seafaring, it is essential that both obey the pilot's instructions. Above all, protests and unrest must be avoided, as these can lead to irrational actions and thus to the immediate failure of the mission. Ibn Mājid is fully aware of this and gives instructions:

Quotation: Look thoroughly at all the passengers and the crew and assess them carefully then you will recognise any evil in them and be prepared for it. Listen to everything they say, accepting anything good and rejecting the bad. Be firm and strong when speaking to them but pleasant. Do not fraternise with the man who disobeys you over any affair of yours. In distress you will not find any companion except secrets kept.[35]

Therefore, it is necessary to keep passengers and crew under constant control. Ibn Mājid assumes they can never be completely trusted. For the navigator, he believes, it is necessary to act strongly and decisively so he is respected and his instructions are followed. Fraternisation also poses a risk. Here, personal impressions and pressure can lead to suboptimal decisions, which in turn jeopardise the smooth running of the mission.

When it comes to order on board a ship, the navigator has a difficult position: he is not only responsible for determining and maintaining the smooth behaviour of passengers and crew. Here, too, the transfer of knowledge and implementation of the resulting tasks are of importance. Ibn Mājid is well aware of this and therefore draws the reader's attention to the problem and advises aspiring navigators.

3.7 Lack of Proper Measurements

The foundation of safe navigation is access to navigation data. Without this, safe voyages are jeopardised. Ibn Mājid gives a few examples of this, which we summarise below.

3.7.1 Lack of position measurements along the Sudanese coast and in the Red Sea

The coast of Bahr Qulzum al-'Arab (Red Sea) follows the Arabian coast then that of the 'Ajam or Qulzum al-'Ajam (here, 'Ajam is a type of fish), i.e., Sudan.[36] Ibn Mājid criticises that the Arabs in their own sea (the Red Sea and along the coast of Sudan) miss out on doing latitude measurements. Apparently, that was the case during and before Ibn Mājid's time. Ibn Mājid presents the reader with a dilemma. He has information about latitude measurements but does not feel confident enough to reveal it to the Seafarers' Guild. He says:

Quotation: No one except me has covered them in my time. I ask pardon of God for any wrong increase or decrease of their values. I have not mentioned them in this book lest foolish men fall upon them and dispute over them with learned men and acquire [falsely] the knowledge of the measurements of this sea and its

[34] Ibn Mājid, *Kitāb al-Fawā'id*, Fourth Fa'ida, 93, line 19. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 154, line 28.

[35] Ibn Mājid, *Kitāb al-Fawā'id*, Eighth Fa'ida, 129, line 21. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 192, line 26.

[36] For more details, see Tibbetts, *Arab Navigation in the Indian Ocean*.

islands. But we have left them out here so that someone will have to travel a great deal in order to know about it (the sea).[37]

Hence, Ibn Mājid regrets that he conducted the missing measurements and was probably the only one in his time who thought it worthwhile to collect this data. At the same time, however, he refrains from disclosing the data now, fearing the information may be subject to minor inaccuracies, which could be held against him. Here, too, he does not trust the target audience for whom this data is intended. He fears triggering unnecessary debates that could potentially lead to unintended chaos.

Finally, Ibn Mājid reveals his information on the geographical latitude measurements. He says:

Quotation: For I would have known nothing about it had not my grandfather - the mercy and the pardon of God be upon him - been well-versed in this sea and my father - God may have mercy on him and pardon him - added still more to this knowledge. I have taken the knowledge of these two men together with much more experience and I have clarified the subject of the of this Qulzumi Sea, in the presence of a circle of more than 20 reliable pilots.[38]

He lets the reader know how he knows that such measurements had been taken in earlier times. It was his immediate ancestors from a family of sailors who carried out these measurements and left them to him. Ibn Mājid also demonstrates, however, that he works according to his motto: 'Experiment and repetition.' He did not uncritically adopt the knowledge of his father and grandfather but combined it with his measurements, which undoubtedly allowed him to verify the data handed down. Only when he is convinced of the information's accuracy does he act and share it with the public. This data should also rightly be made available to the public because the success and safety of all missions will benefit from it.

It is also interesting how he does this. He does not share his knowledge with a single individual, but with a larger group (typically around 20 people) of "reliable pilots." These are experts who will not offer unjustified criticism to gain self-aggrandisement; rather, they understand the data's importance and can properly assess its quality. At the same time, however, Ibn Mājid opens himself up to possible criticism because the pilots who are knowledgeable about the subject matter will also critically examine the new data.

3.7.2 On the position of Suhail with respect to the Southern Celestial Pole

Suhail (Canopus), in the southern constellation Carina, has an 'early' right ascension of 6 hours and 23 minutes. During the year, this means it is mostly of the time located east of the South Pole at dawn, rather than west. So, its location with respect to the South Pole depends on the date rather than on the observer's location.

Quotation: …if you were to ask a sailor he would never know this…and you were to put your question 'When does Suhail east?' they will ask you 'In which country?', but they cannot give you a definite answer to this when you mention a particular country"[39]

Ibn Mājid criticises the common misconception among sailors regarding the star Suhail. When asked when the star is due east, many mistakenly claim its position at dawn depends on the observer's location, failing to realise it depends on the season. This demonstrates a lack of understanding of basic celestial mechanics and an insufficient ability to perform even the simplest navigational observations.

3.7.3 The problem of longitude determination: al-Maraqq wa al-Maghzar

A formidable problem in navigation is determination of exact geographical coordinates. For the geographical latitude, this could be handled by the Arabs very well. Here, basically the Pole height (directly or indirectly through other bright stars) was measured with correction of the *bāshi*[40] (الباشي) – the variation of the

---

37 Ibn Mājid, *Kitāb al-Fawā'id*, Seventh Fa'ida, 127, line 2. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 189, line 9.

38 Ibn Mājid, *Kitāb al-Fawā'id*, Seventh Fa'ida, 127, line 8. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 189, line 16.

39 Ibn Mājid, *Kitāb al-Fawā'id*, Fourth Fa'ida, 70, line 1. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 130, line 32.

40 As the celestial sphere apparently rotates in the sky, the value of the *bāshi* changes as well (for more details, see Tibbetts, *Arab Navigation in the Indian Ocean*; here we summarise to highlight the importance Ibn Mājid had given this fact). Proper measurement of the pole height would include measuring it at a given time then adding to it the *bāshi* as a correction value. In this way, exact knowledge of the pole height could be obtained. These correction values have names corresponding to the lunar mansion that would culminate in the south at the given reference time. The *bāshi* was set to zero when the pole star had its minimum height in altitude, i.e. when it went through lower culmination (Figure 2, left). The lunar mansion *Al-Ṣarfah* (ٱلصَّرْفَة) culminates in the south at that time, giving the *bāshi* its name. *Al-Ṣarfaḥ* – which means "the changer (of the weather)" – is the Arabic name for Lunar Mansion 12. In the Tropical Zodiac, Lunar Mansion 12 extends from 21°26' Leo to 4°17' Virgo. Upper culmination of the pole star,

altitude of the northern polar star (Polaris – الجُدى) due to the fact it is not exactly located at the celestial North Pole. Polaris apparently orbits in a small circle (of diameter ~1.5°) around the North Celestial Pole through the daily rotation of the Earth. See also the schematic in Figure 2, left.

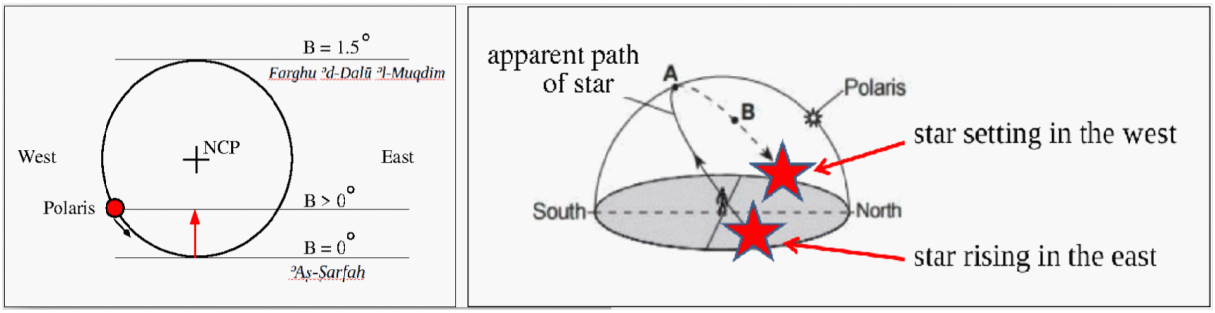


Figure 2: Left: Schematic showing how the polar star Polaris apparently circulates the North Celestial Pole. Here, we show a situation in which Polaris (on its path around the Pole highlighted by a circle) approaches lower culmination (indicated by the curved black arrow). Its current *bāshi* is larger than zero and indicated by the red arrow. For the cases lower culmination (B = 0) and upper culmination (B=1.5, which changes over time due to precession), we give the Arabic names of the lunar mansions that culminate in the south during that time and give the name to the corresponding *bāshi*. Right: This heuristic illustration helps explain the postulated scenario named Al-Maraqq wa Al-Maghzar in a two-dimensional representation of a spherical projection in the sky. In this scenario, the longitude was supposed to be obtained by the observation of the simultaneous rising and setting of two stars. Ibn Mājid points out that this does not work. Here, A and B are random positions of the stellar path and the position of Polaris is indicated.

Figure 2 explains the quantity *bāshi* in more detail. Here, the concept of "trial and repetition" leads to exact measurements; for instance, if they are repeated, compared and averaged. Hence, not correcting for this apparent variation in position may introduce an error of up to ~160 km in the determination of the boat's position. The longitude measurement was more problematic. In the time before Ibn Mājid, it was apparently widely assumed that the longitude of a place could be determined by the combined measurement of the fall and rise of two stars (as depicted in the heuristic illustration in Figure 2, right) – one being towards west and one towards east. This is summarised in the often-reoccurring terms *Al-Maraqq wa Al-Maghzar* (المرقّ والمزر)[41] (it is later also described as the direction towards - مغربًا ومطلعًا – i.e. setting and rising of a star). It was never fully explained how that should work and the method was ridiculed by most recognised navigators. It became clear over the centuries that longitude could only be measured via correct long term time measurements during a journey.

In Ibn Mājid's time, the main method of calculating the longitudinal position, in addition to the latitude measurements, was by calculating the *māsafāt* (مسافات), i.e., by multiplying the speed by the travel time.[42] This included uncertainties from variations in wind and tidal currents in strength and direction (see the schematic of an exemplary vector arrangement in Figure 3).

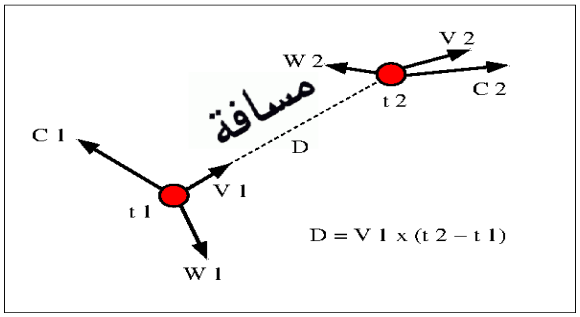


Figure 3: In this schematic we show an exemplary complex situation to calculate the *māsafāt*. Here, we show it for one section, the *māsafa* between position 1 and 2. For position 1, we indicate the current

Polaris, occurs when the lunar mansion *ʾd-Dalū ʾl-Muqdim* (المُقدِم الدّلو فرغ) is going through culmination in the south.

41 Compare entries to مَرَقٌ (m̄rqq̄) and غَزَر (ġz̄r) in Lane, *Arabic English Lexicon*.

42 For more details, see Tibbetts, *Arab Navigation in the Indian Ocean*.

velocity (vector C1), wind velocity (vector W1) and resulting velocity (vector V1) selected by the pilot through the rudder and sail setting. The equivalent quantities are given for position 2. The distance travelled is calculated via the product of V1 and the time difference between the two positions (t2 and t1). For longer journeys, this calculation must be performed several times with results concatenated to obtain the correct distance, i.e., the *māsafāt*.

Concerning the method of *Al-Maraqq wa Al-Maghzar* involving the quasi-simultaneous setting and rising of two stars, Ibn Mājid writes (see also Figure 2, right):

كل شئ لم تدركه الأوأيل والأاخر فادركناه وأتفقوا عليه العلماء من أهل هذا ألفن وأهل ألفلك وأما جهلاء ألمعلمة فهم ألضلال ألقديم ولو سالت واحدا منهم وقدت له تعرف ألمرق قال نعم فيصير جاهلا مركبا لأنه لا يعلم ولا يعلم أنه لا يعلم

Translation: Everything that the first and the later [writers] did not comprehend, we comprehended it, and the scholars of this art (science) and the people of astronomy agreed upon it. As for the ignorant navigators, they stand for the ancient misguidance. If you asked one of them and told him 'Do you know Maraqq wa-maghzar', he would say 'Yes', in compound ignorance, because he (the ignorant navigator) does not know - and he does not know that he does not know.[43]

Tibbetts translates فيصير جاهلا مركبا ... as: '…so that ignorance prevails on this ship.' Then in the final statement of this section, Ibn Mājid criticises the crew's ignorance by saying 'he does not know that he does not know.' This statement reoccurs several times in his remarks on seemingly ignorant sailors or navigators. Hence, this example shows the permanent fight against a false theory of longitude determination that rigorously persisted. Ibn Mājid is trying to clarify the situation and says:

فالثير والواقع دلالة على القاليم لانهم بالعرض لا على المرق والغزر وكثير من الجهلا والبحار مجهول إلى تاريج هذا الكتاب يزعون أن له صحة على جرى مغربا ومطلعا وهو غير صحيح ... الجاهل المركب الذى لا يدرى ولا يدرى انه لا يدرى

Translation: Vega and Sirius are guides in [all] climates because they are for latitude [measurements] and not for Maraqq wa-Maghzar (i.e. longitude measurements) and many of the [ignorant seamen] are ignorant of this book [even] to date. They claim that it (method of Maraqq wa-Maghzar) is correct on the course towards the sunset or the sunrise. And it is not correct…The ignorant [man] is the sailor who does not know and does not know that he does not know.[44]

Hence, he highlights two of the most famous stars used for navigation and underlines their true significance. He emphasises, almost with despair, that they cannot be used to determine longitude. The book he is referring to must be one in which he is currently addressing the reader.

He continues:

Quotation: There are no tricks in this. Had [this method] been accurate with these stars it would have been accurate with other stars which rise and set with them and this would have been sufficient for me if I had not made my research into nautical science.[45]

Here, his scientific approach resonates again: "Trial and repetition." To be convincing, the theory must be tested and proven to work on other stars, i.e., similar cases. That would have satisfied him. However, he continued his studies in astronomy and knew the theory under investigation could not be accurate.

He continues:

فانه متى تحدث به احد الا وقع عليه الحق ودفنوه الجهلا واما مثلي قام يؤخذ على ذلك في الحق

Translation: When you talk to anyone about it - unless the truth falls on him - the ignorant will bury it and if someone like me did it - he is held accountable for that.[46]

The ignorant are not interested in critical discussion of the theory. They are not interested in the theory's verifiability. However, Ibn Mājid, as a righteous scholar, feels held accountable and must constantly strive to clarify the facts. He feels this is required of him. He continues (see Figure 4 derived from the historical SM-53 text copy):

---

[43] Ibn Mājid, *Kitāb al-Fawā'id*, Third Fa'ida, 30, line 6. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 91, line 27.

[44] Ibn Mājid, *Kitāb al-Fawā'id*, Fourth Fa'ida, 80, line 8. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 141, line 4.

[45] Ibn Mājid, *Kitāb al-Fawā'id*, Fourth Fa'ida, 80, line 12. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 141, line 10.

[46] Ibn Mājid, *Kitāb al-Fawā'id*, Fourth Fa'ida, 80, line 14. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 141, line 13.

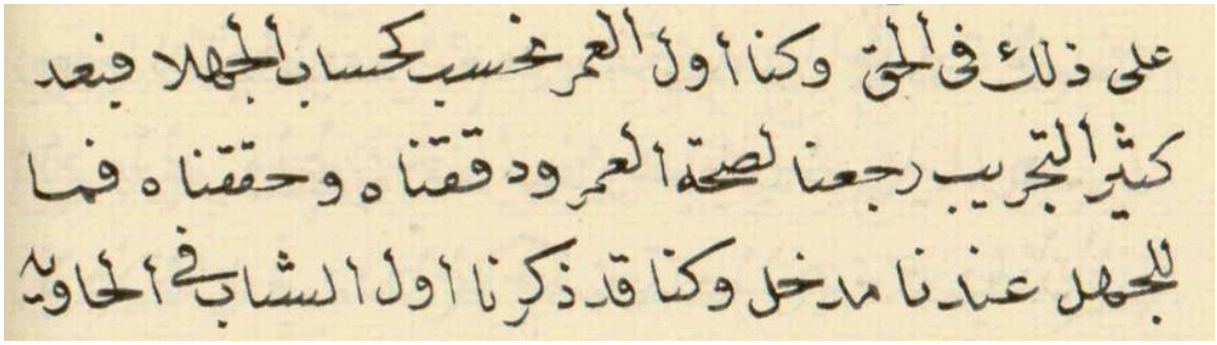


Figure 4: Excerpt from Ibn Mājid in the Fourth *Fa'ida*, 80, line 16, see also Tibbetts, *Arab Navigation in the Indian Ocean*, 141, line 16. He explains how, after much experience ("experimentations," i.e., "trial and repetition"), he tests and corrects traditional information to transform it into verified knowledge. The quotation starts in the middle of the first line and reaches towards the end.

اول العمر نحسب كحساب الجهلا فبعد كثير التجريب رجعنا لصحة العمر ودققناه وحققناه وفما الجهل عندنا مدخل وكنا قد ذكرنا اول الشاب في الحاوية

Quotation: When we were young we did things after the manner of these ignorant men and then after much experience (experimentations) we grew up and examined and corrected things thereby ridding ourselves of ignorance.[47]

He again follows this approach that supports scientific methods: "trial and repetition." Although he initially passed down accepted knowledge due to his youthful ignorance, at an advanced age and with greater experience, he does not accept the knowledge of his ancestors without scrutiny. Everything must be verified, then corrected knowledge can and must be adopted. Through this process, one can free oneself from false knowledge and stay away from it.

IV. SUMMARY AND OUTLOOK

We have presented textual evidence that Aḥmad Ibn Mājid's navigational book *Kitāb al-Fawā'id* contains the concepts of "trial and error" and "methodical doubt," anticipating their attributed development by over 200 years. Additionally, Ibn Mājid's work offers insights into the psychological and physical characteristics of navigators in his era. A detailed discussion of the information extracted from Ibn Mājid's *Kitāb al-Fawā'id* is given in our adjoining paper (Ibn Mājid's *Kitāb al-Fawā'id* and the Concepts of 'Trial and Error' and 'Methodological Doubt' II: Analysis). This will include discussion of the navigator's role in his social environment. We will discuss the concept of "trial and error" and role of "methodological doubt" in Ibn Mājid's *Kitāb al-Fawā'id*. We will also outline Ibn Mājid's position in the philosophical environment of his time and the phenomenon of transfer of knowledge from Arabic sources in the case of Ibn Mājid.

ACKNOWLEDGEMENTS

We extend our sincere thanks to M. Khalid Chakor Alami at the Bibliothèque Nationale de France (BnF) for valuable information regarding the Ibn Mājid manuscript MS2292. Supported by the University of Cologne, this work was undertaken in preparation for the course "Scientific Tradition in Islamic Civilization," presented in January 2026 as part of the SIFHAMS International Graduate Winter School. Special gratitude is extended to Professor Esameldin Agamy, Chancellor of the University of Sharjah, under whose auspices and funding this program was organized by the Sharjah International Foundation for the History of Arab and Muslim Sciences (SIFHAMS), in collaboration with Al Qasimia University (Sharjah, UAE), MES Mampad Autonomous College (India), and the I. Institute of Physics at the University of Cologne (Germany).

APPENDIX

Fa'ida	Fa'ida page	Fa'ida line	Tibbetts page	Tibbetts line
First	6	19	69	1
Second	15	18	77	1
	16	4	77	24
Third	16	19	79	1
	30	6	91	27
	32	22	94	8
Fourth	60	14	121	1
	70	1	130	32
	80	8	141	4

[47] Ibn Mājid, *Kitāb al-Fawā'id*, Fourth Fa'ida, 80, line 16. See also Tibbetts, *Arab Navigation in the Indian Ocean*, 141, line 16.

	80	12	141	10
	80	14	141	13
	80	16	141	16
	86	7	147	10
	93	19	154	28
Fifth	96	4	157	1
Sixth	104	3	165	1
Seventh	108	20	171	1
	127	2	189	9
	127	8	189	16
	127	16	189	29
	128	2	190	10
Eighth	129	6	192	1
	129	21	192	26
	130	4	193	1
	130	6	193	7
	130	18	193	24
Ninth	140	13	204	1
	151	19	215	20
	152	5	215	30
Tenth	152	19	217	1
Eleventh	160	21	225	1
twelfth	177	11	243	1

For better orientation in the SM-53 manuscript at the Library of Congress in Washington, we indicate the page and line for the respective *Fawa'id* – from the first to the twelfth. In addition, we give the corresponding page and line in Tibbetts.

BLIOGRAPHY

[1]. Al-Ġazālī, Abū Ḥāmid. *Deliverance from Error: Five Key Texts Including his Spiritual Autobiography, al-Munqidh min al-Dalal*. [The Rescuer from Error] Translated by Richard J. McCarthy. Fons Vitae, 1999.

[2]. Al-Ġazālī, Abū Ḥāmid. *The Faith and Practice of Al-Ghazali*. Translated by W. Montgomery Watt. George Allen & Unwin, 1953.

[3]. Alwahaib, Mohammad. "Al-Ghazālī and Descartes from Doubt to Certainty: A Phenomenological Approach." *Discusiones Filosóficas* 18, no. 31 (2017): 15–40. https://doi.org/10.17151/difil.2017.18.31.2.

[4]. Descartes, René. *Discourse on the Method*. Translated by Donald A. Cress. Hackett Publishing Company, 1998.

[5]. Eckart, Andreas. "Ibn Raḥīq's Text on the Milky Way: Perception of the Milky Way in the Early Islamic Society." *Arabic Sciences and Philosophy* 29, no. 2 (2019): 227–60. https://doi.org/10.1017/S0957423919000055.

[6]. Eckart, Andreas. "The Early Great Debate: A Comment on Ibn Al-Haytham's Work on the Location of the Milky Way with Respect to the Earth." *Arabic Sciences and Philosophy* 28, no. 1 (2018): 1–30. https://doi.org/10.1017/S0957423917000078.

[7]. Eckart, Andreas. "Use of the Galaxy as a Tool for Spatial and Temporal Orientation during the Early Islamic Period and up to the 15th Century." *Arabic Sciences and Philosophy* 31, no. 1 (2021): 1–44. https://doi.org/10.1017/S0957423920000077.

[8]. Eckart, Andreas, and Mesut Idriz. "Ibn Mājid's Kitāb al-Fawā'id and the Concepts of 'Trial and Error' and 'Methodological Doubt' II: Analysis," *adjacent analysis paper.*

[9]. Eckart, Andreas, and Mesut Idriz. "Knowledge of the Milky Way in the Arabic Cultural Region between the 8th and the 15th Centuries." *Australian Journal of Islamic Studies* 8, no. 3 (2023): 1–15. https://doi.org/10.55831/ajis.v8i3.637.

[10]. Glick, Thomas, Steven Livesey, and Faith Wallis, eds. "Ibn Majid, Ahmad." In *Medieval Science, Technology, and Medicine: An Encyclopedia*, 252. Routledge, 2005. https://doi.org/10.4324/9781315165127.

[11]. Heidarzadeh, Tofigh. "Islamic Astronomical Instruments and Observatories." In *Handbook of Archaeoastronomy and Ethnoastronomy*, edited by Clive L. N. Ruggles, 1917–1925. New York, NY: Springer, 2015. https://doi.org/10.1007/978-1-4614-6141-8_181.

[12]. Ibn Mājid, Aḥmad. *Kitāb al-Fawā'id fī uṣūl 'ilm al-baḥr wa-al-qawā'id* [The book of Benefits on the Principles of Navigation and Nautical Rules]. 1925 (copy of Damascus version). SM-53, Near East Section, Library of Congress, Washington, DC.

[13]. Jackson, Robert, Chris Carter, and Michael Tarsitano. "Trial-and-Error Solving of a Confinement Problem by a Jumping Spider, Portia fimbriata." *Behaviour* 138, no. 10 (2001): 1215–1234. https://doi.org/10.1163/15685390152822184.

[14]. Lane, Edward William. *Arabic English Lexicon*. Williams and Norgate, 1867.

[15]. Saliba, George. "The Role of the *Almagest* Commentaries in Medieval Arabic Astronomy: A Preliminary Survey of Ṭūsī's Redaction of Ptolemy's *Almagest*." In *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam*, 143–162. New York University Press, 1994. See also: Saliba, Georg, "The Role of the Almagest Commentaries in Medieval Arabic Astronomy: A Preliminary Survey of Ṭūsī's Redaction of Ptolemy's Almagest" originally published by George Saliba as a journal article in Archives internationales d'histoire des sciences (Vol. 37, No. 118, pp. 3–20) in 1987.

[16]. Tibbetts, Gerald. *Arab Navigation in the Indian Ocean Before the Coming of the Portuguese*. Oriental Translation Fund, vol. 42. Royal Asiatic Society of Great Britain and Ireland, 1971. Reprint, 1981.

[17]. Tolmacheva, Marina. "An Unknown Manuscript of the *Kitāb al-Fawāi'd*." [The book of Benefits]; *Journal of the American Oriental Society* 114, no. 2 (1994): 259–262. https://doi.org/10.2307/605135.