

QIBLA DIRECTION DETERMINATION: A SYSTEMATIC LITERATURE REVIEW ON THE ROLE OF MATHEMATICS IN ISLAMIC EDUCATION

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ABSTRACT

Accurate Qibla direction is a fundamental aspect of Muslim worship, especially in prayer. However, many studies have reported significant inaccuracies in Qibla determination, particularly in areas lacking proper astronomical tools or knowledge. At the same time, interest in mathematics among students in Islamic education remains relatively low, despite its critical role in religious practices. This study aims to systematically review recent literature that explores the role of mathematics in Qibla direction determination and its integration into Islamic education. A Systematic Literature Review (SLR) was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Fourteen articles published between 2020 and 2024 were selected from indexed journal databases based on specific inclusion and exclusion criteria. Data collection involved document analysis of journal articles, books, and theses using relevant keywords such as "Qibla direction," "Islamic education," and "mathematics." The selected articles were analyzed thematically and categorized based on year of publication, mathematical concepts applied (e.g., spherical trigonometry), and educational integration. The results show that mathematical approaches particularly spherical trigonometry play a central role in achieving high accuracy in Qibla direction determination. Furthermore, the integration of these mathematical concepts into Islamic education enhances students' understanding of the connection between science and religion. This review suggests that embedding mathematical applications into Islamic contexts can increase student motivation and strengthen the relevance of mathematics in daily worship.

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INTRODUCTION

Qibla direction holds a significant role in the performance of Islamic rituals, particularly in the observance of prayer (shalat) (Fais et al., 2024:1770). Muslims are required to face the Kaaba during prayer, as facing the Qibla is one of the essential conditions for the validity of shalat (Soleiman, 2016:2). This command is clearly stated in the Qur'an, Surah Al-Baqarah verse 144, which directs Muslims to face the Kaaba as the central point of worship. Beyond being a symbol of devotion, the Qibla direction also represents the unity of Muslims worldwide (Mahtir & Ridwan, 2020:2).

In the early days of Islam, the determination of Qibla direction was carried out through simple methods, such as direct observation of the Kaaba's position in Mecca. Before the command to face the Kaaba, Muslims initially faced Bayt al-Maqdis in Jerusalem. However, after the revelation was received, the Qibla was changed to the Kaaba. At that time, direct observation was based on the position of the sun, stars, or other natural signs (Thoyfur, 2021:42). This reflects the close relationship between religion and the universe as understood in Islam. Over time, the advancement of science and technology—including developments in mathematics and astronomy—has significantly impacted Qibla determination, making the process more accessible. One notable figure in this development was Al-Biruni (973–1048), who employed the concept of spherical trigonometry to calculate the Qibla direction from various parts of the world (Pratama, 2022:4).

Mathematics has contributed broadly to several Islamic sciences, including *ilm al-falak* (astronomy), which is used to determine Qibla direction and the Hijri calendar through precise astronomical calculations (Fauzan et al., 2023:109). In *ilm faraid* (Islamic inheritance law), mathematical operations ensure fair distribution of wealth according to Sharia (Shadat & Iqbal, 2023:48). Similarly, in Islamic economics, mathematical concepts are applied in calculating zakat, nisab, and in designing Sharia-compliant financial systems that avoid *riba* (interest). Even in the science of tafsir (Qur'anic exegesis), quantitative analysis is used to explore numerical patterns within the Qur'an. For instance, Noperta (2023:6-8) demonstrated that the Qur'an contains various mathematical concepts such as numbers, greatest common divisors and least common multiples, sets, geometry, sequences, logic, statistics, and linear equations. Thus, learning mathematics not only provides worldly benefits but also becomes a means of contemplating God's greatness and the divine order in life and the universe. In the context of Qibla direction, mathematics plays a crucial role in achieving high accuracy (Azizah, 2024:33121). Through mathematical approaches, Muslims are taught how mathematical concepts such as geometry and trigonometry can be used to accurately determine the direction of the Kaaba. This demonstrates to students that mathematics is not merely abstract theory but is highly relevant to daily practices, including acts of worship.

The integration of mathematics in Islamic education dates back to the golden age of Muslim scholars in the 8th century (Ananda et al., 2022:111). During this period, Muslim scientists played a vital role in the development of various scientific disciplines, including mathematics, astronomy, geometry, and algebra. Prominent scholars such as Al-Khwarizmi—known as the father of algebra—along with Al-Battani and Omar Khayyam, made major contributions to the advancement of mathematical sciences (Fauzan et al., 2023:125). Al-Khwarizmi also played a role in the development of the decimal number system and the use of zero as a numeral, which enabled more complex and accurate calculations (Syaf et al., 2018). These scholars not only introduced new mathematical concepts but also integrated them with Islamic teachings. The Islamic education system at the time promoted a deeper understanding of the relationship between science and religion. Mathematics was taught with the goal of helping Muslims comprehend natural laws established by Allah and fulfill their duties as *khalifatullah* (vicegerents of God) on Earth (Widyaningrum, 2022:65).

Returning to Qibla determination, the application of mathematical concepts such as spherical triangles and trigonometry demonstrates the significant contribution of mathematics to the religious life of Muslims. However, Nugraha et al. (2023:109) found that in Islamic boarding schools (pesantren), students tend to show less interest in mathematics compared to religious studies—even though these students are expected to contribute to religious practices in society. In line with the essential role of mathematics in Islamic education, particularly in determining Qibla direction, a study conducted at Al-Istiqomah Mosque in Ketejen Village found a 22° azimuth deviation between trigonometric calculations and measurements taken with instruments such as theodolites and calculators (Ramadhan, 2021:69). Another study by Soleiman (2016:79) in several mosques in Jakarta revealed significant Qibla deviations ranging from 2° to 4°. These cases underscore the importance of accuracy in Qibla determination, which can directly affect the validity of prayer. Therefore, there is a need for more innovative integration of mathematics into Islamic education, illustrating how science—especially mathematics—plays an essential role in understanding and practicing Islamic teachings.

A review of existing literature shows several previous studies discussing the role of mathematics in Islamic education. For example, Azmi & Salam (2022) explored the integration of Islam and mathematics in the curriculum but did not focus on specific methods for determining Qibla direction. Similarly, Fitrah & Kusnadi (2022) examined the integration of Islamic values in mathematics education in general, without highlighting practical applications such as Qibla determination. These studies tend to be general and do not specify which mathematical concepts are crucial in Islamic education. In contrast, the current study focuses specifically on the practical application of mathematics—particularly spherical trigonometry—in determining the Qibla direction, a vital aspect of Muslim worship. While previous studies addressed broader themes, this review emphasizes the direct relationship between mathematics and religious practice, namely Qibla direction determination.

This literature review aims to identify the distribution of studies with the keywords Qibla direction determination, the role of mathematics in Islamic education, and the role of mathematics in Qibla direction determination, based on their year of publication. It also seeks to examine the role of mathematics—particularly spherical trigonometry—in Qibla determination, and analyze how mathematical concepts are integrated into Islamic education. To achieve these goals, the study poses several research questions: (1) What literature related to Qibla determination has been published in the last five years? (2) What is the role of spherical trigonometry in Qibla direction determination? and (3) How are mathematical concepts integrated into Islamic education? By analyzing various sources and previous studies following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, this article aims to provide new insights and perspectives while encouraging greater student interest in mathematics, especially within Islamic education settings.

METHOD

This study employs the Systematic Literature Review (SLR) method to examine literature related to the role of mathematics in Islamic education, with a specific focus on Qibla direction determination. SLR was chosen as it allows researchers to identify, evaluate, and interpret a wide range of research findings relevant to a particular research question or topic of interest (Triandini et al., 2019:64). According to Norlita et al. (2023:212), this method begins with searching and identifying articles related to the research topic, which are then analyzed. The implementation of this SLR follows the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. According to Page et al. (2021:9), PRISMA involves several key steps, namely identification, screening, data extraction, and synthesis or analysis.

This study adopts a descriptive qualitative approach, which aims to provide a clear and concise understanding of a phenomenon based on the available data, while maintaining close alignment with the original narratives and avoiding high levels of theoretical abstraction (Sandelowski, 2000:334).

The data sources in this study consist of supporting documents, including scientific journal articles, books, and theses relevant to the research focus. Data collection was conducted using documentary techniques. According to Sugiyono (2015:329), documentary techniques refer to methods used to collect data and information from various sources such as books, archives, documents, statistical records, and images that contain relevant reports and explanations for the research. These documents were accessed through several academic platforms such as Google Scholar, ResearchGate, and Publish or Perish, using relevant keywords.

At the eligibility stage, the researcher reviewed all identified articles. One of the main criteria for inclusion was the year of publication; only articles published within the last five years (2020–2024) were selected. Articles that did not address the variables of Qibla direction, the role of mathematics, and Islamic education were excluded from the review. The criteria used to determine article inclusion are presented as follows:

Table 1. Inclusion and Exclusion Criteria

No.	Inclusion Criteria	Exclusion Criteria
1.	Publications between 2020 and 2024.	Publications between 2020 and 2024.
2.	Articles published in journals indexed in SINTA 1 to SINTA 4.	Articles published in journals indexed in SINTA 1 to SINTA 4.
3.	Articles specifically related to Qibla Direction Determination, Mathematics, and Islamic Education.	Articles specifically related to Qibla Direction Determination, Mathematics, and Islamic Education.
4.	Articles that include the role of mathematics in Islamic education, with a focus on Qibla direction.	Articles that include the role of mathematics in Islamic education, with a focus on Qibla direction.

From the initial search, a number of articles were identified; however, after applying the inclusion and exclusion criteria, 14 relevant articles were selected. The data were analyzed using content analysis to identify key themes, methodological approaches, and the contributions of mathematics to the practice of Qibla direction determination and Islamic education. All search and selection results in this study are illustrated in the PRISMA Flow Diagram in Figure 1.

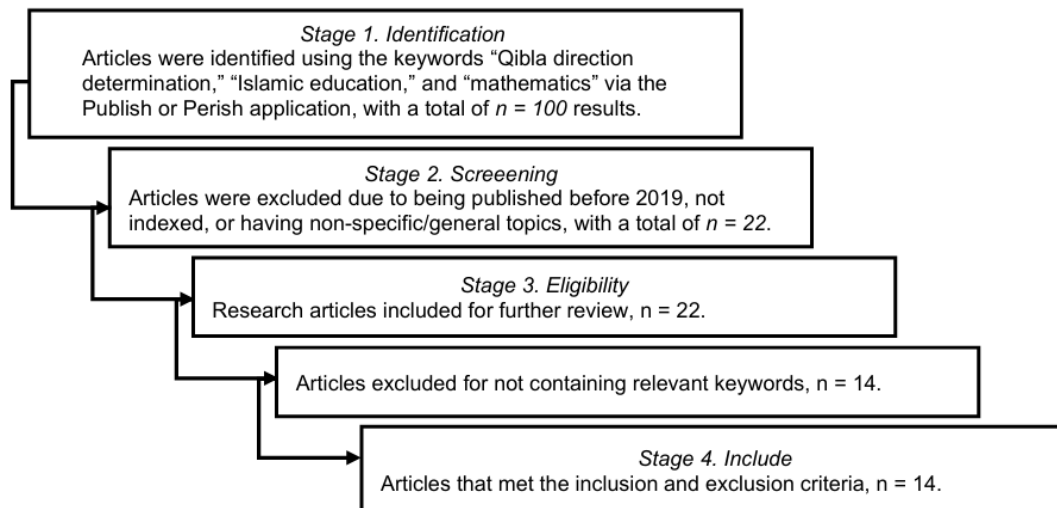


Figure 1. PRISMA Flow Diagram

RESULTS AND DISCUSSION

Results

A total of 14 articles were selected for analysis based on literature related to Qibla direction determination in the last five years, the role of spherical trigonometry in Qibla determination, and the integration of mathematics in Islamic education. The following section presents the analysis results of the 14 selected articles, which were filtered based on inclusion and exclusion criteria.

Study Based on Article Distribution by Year of Publication. The analysis of article distribution by year of publication shows that 14 articles met the criteria for further review. The data on the selected articles from the years 2020 to 2024 is presented in Figure 2.

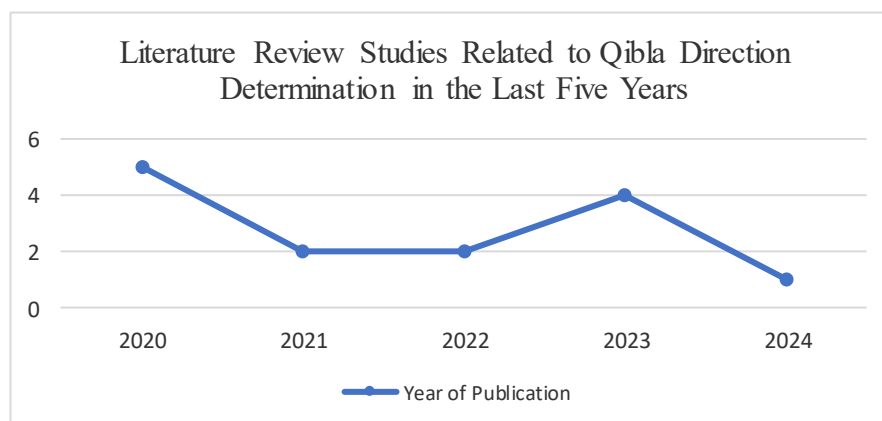


Figure 1. Criteria Based on Year of Publication

In this study, the researcher only included articles published within the last five years, specifically between 2020 and 2024. This time range was selected to ensure the inclusion of up-to-date, relevant literature that reflects the latest developments related to Qibla direction determination and its integration with mathematical concepts in Islamic education. Among the 14 articles analyzed, the publication year distribution shows that the majority were published in the last two years, namely in 2022 and 2023. This indicates that the topic of Qibla direction and the integration of mathematics within the context of Islamic education remains an actively researched and evolving area.

Of the 14 articles published in the last five years, it can be seen that the literature related to Qibla direction determination is not limited to studies that directly examine the topic. For instance, Kariadinata & Nuraida (2020), Ahmad & Tasni (2020), and Cholis et al. (2024) discuss Qibla determination within the context of education, while Jannah (2023), Solikin (2020), Solikin (2020b), Armi et al. (2022), and Azmi & Ukhti (2023) explore the topic through mathematical discussions. Other articles focus directly on Qibla direction using a variety of methods, including both traditional and modern approaches. This review shows that Qibla determination is not merely viewed as a ritual matter, but has also become a subject of scientific inquiry involving mathematics, astronomy, technology, and education. This indicates that over the past five years, scholarly attention toward this topic has steadily increased and it has become an important part of the integration between science and Islamic teachings.

Study Based on the Role of Spherical Trigonometry in Qibla Direction Determination
A total of 14 relevant articles were identified that discuss the role of spherical trigonometry in determining the Qibla direction. The data of the articles selected for analysis are presented in Table 2.

Table 2. Criteria Based on the Role of Spherical Trigonometry in Qibla Direction Determination

No	Article Title	Analysis Result
1	Peningkatan Pemahaman Matematis Guru MA Persis dalam Menyelesaikan Masalah Ilmu Falak (Kariadinata & Nuraida, 2020)	This article demonstrates how mathematics plays a role in Islamic law, including Qibla direction determination. The authors highlight the importance of understanding trigonometric concepts to solve problems related to Ilmu Falak.
2	Integrasi Alquran pada Mata Kuliah Trigonometri (Ahmad & Tasni, 2020a)	This study links Qur'anic values with the teaching of trigonometry, particularly in the context of Qibla direction calculation. Using trigonometric formulas, the article shows how understanding mathematical concepts can improve accuracy in determining the Qibla direction.
3	Pertemuan Rumus Cosinus dan Sinus dengan Haversine dalam Perhitungan Arah Kiblat (Solikin, 2020b)	This article explicitly discusses the use of cosine, sine, and Haversine formulas in Qibla direction calculations. The author explains their interrelation and application for more accurate Qibla positioning.
4	Telaah Matematis Perhitungan Arah Kiblat Rumus Cos-Sin Dengan Rumus Tan dalam Dasar-Dasar Ilmu Ukur Segitiga Bola (Solikin, 2020a)	This study analyzes trigonometric formulas relevant to Qibla direction calculations, with emphasis on the tangent formula and the relationship between angles and distances on a spherical surface.

5	Perancangan Aplikasi Arah Kiblat dan Jadwal Waktu Shalat Berbasis Android “AQ-Shalat” (Sunardi et al., 2021)	This article discusses the use of modern technology to validate Qibla direction calculations using spherical trigonometry. The authors show that technology can help minimize errors in Qibla determination.
6	Penggunaan <i>Google Earth</i> Sebagai <i>Calibrator</i> Arah Kiblat (Mustaqim, 2021)	This article also discusses the use of modern tools to validate Qibla direction calculations based on spherical trigonometry, highlighting the role of technology in reducing directional errors.
7	Penggunaan GeoGebra untuk Meningkatkan Pemahaman Matematis Mahasiswa dalam Menentukan Arah Kiblat (N. Azmi & Ukhti, 2023)	This article explains how GeoGebra serves as a visual aid to enhance understanding of spherical trigonometry concepts in determining the Qibla direction.
8	Pengaruh Pemikiran Abu Raihan Al-Biruni terhadap Perkembangan Ilmu Falak (Jannah, 2023)	This article highlights the contribution of Muslim scholar Al-Biruni to the development of spherical trigonometry, particularly in Islamic astronomy and Qibla direction. It discusses the use of spherical triangles and classical mathematical approaches.
9	Pengembangan Bahan Ajar Matematika Falak untuk MA (Cholis et al., 2024)	This article addresses the integration of spherical trigonometry into Ilmu Falak mathematics teaching materials. Topics include the use of sine and cosine formulas in the celestial sphere context for teaching Qibla direction.

The analysis of the relevant articles shows that spherical trigonometry plays a significant role in Qibla direction determination, both theoretically and practically. In the theoretical context, articles such as Ahmad & Tasni (2020) explain the use of trigonometric formulas like cosine and sine, while Solikin (2020a) discusses the integration of cosine, sine, and Haversine formulas to calculate the Qibla direction with high accuracy. This approach enables Muslims to understand the relationship between angles and distances on the Earth's spherical surface. In addition, several articles emphasize the importance of Ilmu Falak education in enhancing mathematical understanding related to Qibla direction. For instance, the study by Kariadinata & Nuraida (2020) highlights that integrating Islamic values into mathematics education can help students better grasp the concepts of spherical trigonometry. From an applied perspective, modern technology also plays a significant role in supporting the accuracy of Qibla determination. The article by Mustaqim (2021) demonstrates how Google Earth is used as a calibration tool for Qibla direction, while the study by N. Azmi & Ukhti (2023) discusses the use of GeoGebra to interactively visualize spherical trigonometry concepts.

Study Based on the Integration of Mathematical Concepts in Islamic Education. A total of 14 articles were found to be relevant to the integration of mathematical concepts in Islamic education. The mathematical concepts analyzed in this study are limited to the fields of

geometry, trigonometry, and astronomy. The data of the selected articles for analysis are presented in Table 3.

Tabel 3. Criteria based on Integration Mathematics Concept on Islamic Education

No.	Mathematical Concept	Frequency of Use
1	Geometry	11
2	Trigonometry	2
3	Astronomy	1

The analysis results show that the integration of mathematical concepts in Islamic education plays a significant role, particularly in the context of Qibla direction determination. Based on the table provided, the three main mathematical concepts frequently used are geometry, trigonometry, and astronomy. Among the 14 articles analyzed, trigonometry emerged as the most dominant concept, appearing in 11 articles, followed by geometry (2 articles) and astronomy (1 article). Trigonometry is employed to calculate geographic angles and distances toward the Kaaba, using formulas such as sine, cosine, and Haversine. Geometry contributes to understanding spatial position and orientation, such as using the sun's shadow to visually determine the Qibla direction. Meanwhile, astronomy is utilized to calculate the positions of celestial bodies relevant to Qibla alignment.

This integration is not only theoretical but also practical within the Islamic education curriculum. Several articles highlight the teaching of Ilmu Falak (Islamic astronomy) in higher education as part of mathematics or astronomy courses. For instance, students are taught to apply spherical trigonometry formulas for accurate Qibla direction determination. In addition, teacher training programs in madrasahs also include the application of Ilmu Falak in mathematics education to enhance students' understanding of the connection between scientific knowledge and religious practice.

This study also reveals that modern technologies, such as Android-based applications and GeoGebra software, have been utilized to support the learning of Qibla direction concepts. This highlights the relevance of mathematics in Islamic education by combining traditional approaches with technological innovation. In conclusion, such integration not only enriches the curriculum but also provides students with practical understanding of the importance of mathematics in supporting the proper performance of religious rituals in accordance with Islamic law.

Discussions

Study Based on Article Distribution by Year of Publication. Literature on Qibla Direction Determination in the Last Five Years. The literature over the past five years indicates that Qibla direction determination remains an evolving topic, both in terms of the methods and approaches used. The analyzed articles explore a variety of techniques for determining the Qibla direction, ranging from traditional methods such as *Rashdul Qibla* to modern technologies like Qibla Finder applications, Google Earth, and GPS. The use of such technologies has significantly improved the accuracy of Qibla direction, particularly in remote areas or regions with limited access to conventional methods.

These findings are consistent with Sahputra (2017:1) argument that the determination of Qibla direction today no longer relies solely on visual methods or simple tools, but has increasingly adopted scientific, technology-based approaches. Such approaches not only simplify the process of determining Qibla direction but also enhance public confidence in the accuracy of the direction used during worship. In addition, the literature review emphasizes the importance

of community education and training for teachers or religious leaders in understanding scientific methods of Qibla determination, so they can effectively convey accurate information within their respective communities.

Study Based on the Role of Spherical Trigonometry in Qibla Direction Determination. Spherical trigonometry is the most dominant mathematical concept used in the reviewed articles. Most of the studies apply spherical trigonometric formulas such as cosine, sine, and haversine to calculate the azimuth angle of the Qibla direction based on the latitude and longitude coordinates of a location in relation to the Kaaba. This approach is employed to achieve more precise results compared to traditional methods, and its effectiveness has been demonstrated in various case studies. This is supported Jayusman (2022:32), who states that spherical trigonometry is one of the most essential branches of mathematics in *Ilmu Falak*, particularly in the context of Qibla direction determination.

The mathematical determination of the Qibla direction involves the use of a spherical triangle, a triangle whose sides are arcs of great circles on the surface of the Earth. In this calculation, three main variables are used:

1. Latitude of the location (ϕT), which indicates the position north or south relative to the equator.
2. Latitude of the Kaaba (ϕK), which is fixed at approximately 21,4225° N.
3. Longitude difference ($\Delta\lambda$) between the observer's location and the Kaaba, calculated based on the respective geographic longitudes.

The cosine formula in spherical trigonometry is used to determine the Qibla azimuth (B):

$$\cos B = \frac{\sin \phi K - \sin \phi T \cos A}{\cos \phi T \sin A}$$

Where A is the angular distance between the observer's location and the Kaaba, obtained using the spherical triangle law:

$$\cos A = \sin \phi T \sin \phi K + \cos \phi T \cos \phi K \cos \Delta\lambda$$

In addition, Solikin (2020b) study also reveals the use of the Haversine formula in determining the Qibla direction, which is defined as:

$$d = 2r \arcsin \sqrt{\sin^2 \left(\frac{\Delta\phi}{2} \right) + \cos \phi T \cos \phi K \sin^2 \left(\frac{\Delta\lambda}{2} \right)}$$

Where d is the distance between the observer's location and the Kaaba, and r is the radius of the Earth.

Through this approach, Muslims can accurately calculate the Qibla direction without relying on direct observational methods, which are prone to errors. In practice, this method has been implemented in various modern technologies, such as smartphone applications that use spherical trigonometry algorithms to provide real-time Qibla direction based on the user's GPS coordinates; digital mapping software like Google Earth and GeoGebra, which allow visualization of the Qibla direction based on Earth's geometric model; and traditional astronomical instruments such as the theodolite, which utilize spherical trigonometric calculations to manually calibrate the Qibla direction.

This study also reveals that the use of spherical trigonometry-based technology is effective in correcting Qibla direction deviations still found in several mosques and cemeteries. For example, some studies have shown deviations ranging from 5° to 15° due to errors in using

non-mathematical methods. A study by Hosen & Nurhalisa (2019) found that cemeteries in Ponteh Village experienced significant Qibla direction deviations caused by manual calculation errors. Solikin (2020b) investigated the role of cosine, sine, and Haversine formulas in Qibla determination, emphasizing that spherical trigonometric methods are more accurate than traditional approaches. Additionally, another study by Solikin (2020a) examined Qibla direction calculations using a combination of cosine-sine and tangent formulas, showing that mathematical approaches produce more precise results compared to conventional methods.

Study Based on the Integration of Mathematical Concepts in Islamic Education
The findings indicate that spherical trigonometry is not only relevant in the context of Islamic astronomy but also holds significant educational value. Several key insights from this study include the use of trigonometry in Islamic education curricula—particularly in *Ilmu Falak*—to train students in understanding geographic coordinates and calculating the Qibla direction; the integration of technology-based learning, where students utilize software such as GeoGebra to simulate Qibla calculations interactively; and research showing that applying mathematical formulas such as cosine-sine, tangent, and Haversine not only deepens students' understanding of trigonometric concepts but also strengthens the connection between mathematics and religious practice. (Fitrah & Kusnadi, 2022:162) explain that the integration of science and Islamic values is a vital component of the Islamic education system. This approach not only enhances students' comprehension of mathematical material but also instills religious and spiritual values within the learning process. Furthermore, by employing contextual approaches grounded in acts of worship, students become more motivated as they find that the material being studied has direct meaning in their lives as Muslims. Therefore, the integration of mathematical concepts in Islamic education through the topic of Qibla direction determination serves as concrete evidence that science and religion can coexist harmoniously in shaping holistic and meaningful learning experiences.

Based on the analysis and discussion of the 14 selected articles, it can be concluded that the determination of the Qibla direction has been a continuously evolving topic over the past five years, in terms of methods, technology, and its application within the context of Islamic education. Spherical trigonometry has proven to be the most widely used mathematical concept in the scientific calculation of Qibla direction, while the integration of mathematical concepts in Islamic education demonstrates that learning can be conducted in a contextual and spiritually meaningful manner. This study also highlights a strong connection between the findings of the literature review and the theoretical framework presented in the previous chapters. Accordingly, this review provides a comprehensive understanding of the role of mathematics in Qibla direction determination and its contribution to value-based Islamic learning. The next chapter will present the overall conclusions of the study along with suggestions for future research development.

CONCLUSION

Based on the analysis of 14 articles published in the past five years, it was found that the determination of the Qibla direction has undergone significant development through the application of scientific approaches and modern technology, thereby achieving greater accuracy in accordance with Sharia principles. In addition, this study reveals that spherical trigonometry has proven to be the dominant mathematical concept used in the Qibla determination process. Calculations based on latitude and longitude using spherical triangle formulas enable precise Qibla direction determination, whether conducted manually or with the aid of digital tools. This demonstrates that mathematics serves not only as a computational tool but also as a means to support the accuracy of religious practices.

The mathematical concepts used in Qibla determination have also begun to be integrated into Islamic education. Several articles indicate that teachers and lecturers are developing instructional methods that combine mathematical material with religious practice—such as calculating the Qibla direction in trigonometry or geometry lessons. This approach not only contextualizes the learning experience but also embeds spiritual values within students.

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