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Strengthening Student Astronomical Literacy through Qibla Direction Measurement: Educational Reflections at As'adiyah Islamic University Sengkang

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Abstract

Astronomical literacy (falak literacy) represents an essential competency for Islamic university students, particularly in understanding religious practices grounded in astronomical calculations. This reflective article examines the educational implementation of qibla direction measurement as a pedagogical tool to strengthen astronomical literacy among students at As'adiyah Islamic University Sengkang. Through systematic observation and educational practice, qibla direction measurement serves not only as a practical skill but also as a bridge connecting theoretical astronomical knowledge with religious practice. The integration of traditional Islamic astronomical methods with contemporary measurement techniques demonstrates significant potential in enhancing student comprehension of celestial mechanics, spherical geometry, and geographical orientation. This educational reflection explores how hands-on qibla measurement activities foster deeper understanding of astronomical concepts while simultaneously reinforcing the relevance of Islamic astronomy in contemporary Muslim life. The findings suggest that experiential learning through qibla direction measurement effectively cultivates critical thinking, spatial reasoning, and interdisciplinary connections between Islamic studies and natural sciences.

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INTRODUCTION

Astronomical literacy, particularly within the Islamic educational context, encompasses more than mere comprehension of celestial phenomena; it represents a fundamental capability that integrates scientific knowledge with religious practice and cultural heritage. In contemporary Islamic higher education, the challenge of maintaining relevant and engaging astronomical education has become increasingly critical as students navigate between traditional Islamic sciences and modern scientific methodologies. As noted by Ihsanuddin (2020), Islamic astronomy or ilmu falak serves as a unique discipline that bridges classical Islamic scholarship with contemporary astronomical science, requiring educators to develop innovative pedagogical approaches that honor both traditions while meeting modern educational standards. The preservation and advancement of astronomical literacy among Muslim students is not merely an academic concern but a matter of preserving Islamic intellectual heritage and ensuring the continuation of religiously informed scientific practice.

At As'adiyah Islamic University Sengkang, located in South Sulawesi, Indonesia, the challenge of developing robust astronomical literacy among students reflects broader patterns observed across Islamic educational institutions in Southeast Asia. Students often encounter difficulties in conceptualizing abstract astronomical concepts such as celestial sphere geometry, coordinate systems, and the relationship between terrestrial and celestial positions. According to Hambali (2022), many Islamic university students demonstrate limited practical understanding of astronomical calculations despite possessing theoretical knowledge, suggesting a disconnect between classroom instruction and applied competency. This pedagogical gap becomes particularly evident when students attempt to apply astronomical principles to practical religious contexts, such as determining prayer times, establishing the Islamic calendar, or identifying the qibla direction. The need for experiential learning methodologies that can effectively bridge theoretical knowledge with practical application has become increasingly apparent in contemporary Islamic astronomical education.

Qibla direction determination represents one of the most universally relevant applications of Islamic astronomy, as every Muslim worldwide requires accurate knowledge of the qibla for the performance of obligatory prayers. Azhari (2021) emphasizes that qibla determination encompasses multiple dimensions of astronomical literacy, including understanding of geographical coordinates, spherical trigonometry, great circle navigation, and the relationship between observer position and the target location of the Kaaba in Mecca. The process of measuring and calculating qibla direction inherently engages students with fundamental astronomical concepts while providing immediate practical relevance to their religious lives. This dual significance—both scientific and devotional—makes qibla direction measurement an ideal pedagogical vehicle for developing comprehensive astronomical literacy. Furthermore, the hands-on nature of qibla measurement activities aligns with

constructivist learning principles that emphasize active student engagement in knowledge construction through direct experience and problem-solving.

The educational context at As'adiyah Islamic University presents both opportunities and challenges for implementing innovative astronomical education. As an institution with deep roots in traditional Islamic scholarship while simultaneously engaging with modern educational standards, the university serves students from diverse educational backgrounds, many of whom have limited prior exposure to astronomical sciences. Research by Jayusman and Shavab (2020) indicates that effective integration of traditional Islamic knowledge with contemporary scientific methods requires carefully designed pedagogical interventions that respect both epistemological frameworks while facilitating meaningful learning. The qibla direction measurement activities implemented at the university thus represent not merely a technical exercise but a carefully considered educational intervention designed to honor Islamic astronomical traditions while employing modern pedagogical best practices. This approach recognizes that astronomical literacy in the Islamic educational context must encompass both technical competency and cultural-religious understanding.

Experiential learning theory provides crucial theoretical foundation for understanding why hands-on qibla measurement activities prove effective in developing astronomical literacy. Kolb's experiential learning cycle, which emphasizes concrete experience, reflective observation, abstract conceptualization, and active experimentation, aligns naturally with the process of learning through qibla direction measurement (Kolb & Kolb, 2023). When students physically engage with measurement instruments, observe celestial phenomena, calculate coordinates, and verify their results, they move through all phases of the learning cycle, thereby constructing deeper and more durable understanding. The tactile and spatial dimensions of qibla measurement activities engage multiple learning modalities simultaneously, supporting diverse learning preferences and cognitive styles. Moreover, the immediate feedback provided by comparing calculated and measured qibla directions enables students to identify and correct misconceptions in real-time, a pedagogical advantage that purely theoretical instruction cannot provide.

The contemporary relevance of qibla direction determination extends beyond individual religious practice to encompass broader societal needs, including mosque construction, Islamic institutional development, and the provision of qibla direction services to Muslim communities. Sakirman (2021) argues that Islamic universities bear particular responsibility for producing graduates capable of serving their communities through applied astronomical knowledge, including the provision of accurate qibla direction determinations. The proliferation of digital technologies and smartphone applications claiming to provide qibla direction has paradoxically increased rather than decreased the need for astronomical literacy, as users require critical evaluation skills to assess the reliability and accuracy of such technologies. By developing robust astronomical literacy through hands-on qibla measurement experiences, students at As'adiyah Islamic University are prepared not only to

serve their own religious needs but also to function as resources for their broader communities, evaluating and improving the astronomical services available to fellow Muslims.

DISCUSSIONS

Theoretical Foundations of Qibla Direction in Islamic Astronomy

The determination of qibla direction represents a sophisticated application of spherical astronomy that has engaged Muslim scholars for over fourteen centuries, producing a rich intellectual tradition that continues to inform contemporary practice. At its foundation, qibla direction calculation requires understanding the Earth as a sphere and conceptualizing the shortest path between two points on that sphere as a great circle arc rather than a straight line on a flat surface. As Izzuddin (2022) explains, this fundamental insight—that the qibla direction follows a great circle route rather than a rhumb line—distinguishes sophisticated astronomical understanding from naive geographical intuition. Students often enter qibla direction studies with the misconception that qibla direction can be determined simply by drawing a straight line on a flat map between their location and Mecca, a misunderstanding that hands-on measurement activities effectively challenge and correct. The recognition that Earth's sphericity fundamentally affects directional calculations represents a crucial threshold concept in developing authentic astronomical literacy.

Classical Islamic astronomers developed multiple methods for qibla determination, ranging from mathematical calculations using spherical trigonometry to observational techniques utilizing celestial phenomena such as solar positions and stellar alignments. The mathematical approach, formalized by scholars such as al-Biruni and al-Battani, employs the haversine formula or similar spherical trigonometric relationships to calculate the azimuth angle from the observer's location to Mecca. According to Hambali (2020), understanding these classical calculation methods provides students with deeper appreciation of Islamic scientific heritage while simultaneously developing their mathematical reasoning capabilities. The formula for qibla direction typically involves the geographical coordinates (latitude and longitude) of both the observer's location and the Kaaba, utilizing spherical trigonometric functions to determine the precise azimuth. When students work through these calculations themselves, they develop not only computational skills but also conceptual understanding of how geographical position, spherical geometry, and trigonometric relationships interact to determine directional orientation.

Beyond pure calculation, observational methods for qibla determination provide valuable pedagogical opportunities for engaging students with practical astronomical observation and measurement techniques. The *rashd al-qibla* phenomenon, when the sun passes directly over the Kaaba twice yearly, offers a particularly elegant observational method for qibla verification, as objects' shadows point directly toward or away from the

qibla at these moments. Azhari (2020) notes that incorporating such observational methods into qibla direction education connects students with centuries-old Islamic astronomical practices while developing their skills in systematic observation and data interpretation. The use of solar compasses, shadow tracking, and stellar observation for qibla determination engages students in authentic astronomical practice that extends beyond abstract calculation to encompass direct engagement with celestial phenomena. This multifaceted approach to qibla direction—combining calculation, observation, and measurement—provides rich opportunities for developing comprehensive astronomical literacy.

The integration of modern measurement technologies with traditional Islamic astronomical methods presents contemporary educators with both opportunities and challenges in qibla direction education. Digital tools such as GPS receivers, electronic compasses, theodolites, and smartphone applications can enhance measurement accuracy and efficiency while potentially obscuring the underlying astronomical principles if used uncritically. Kamaluddin et al. (2021) argue that effective astronomical education must balance technological proficiency with conceptual understanding, ensuring that students comprehend the astronomical foundations underlying digital tools rather than treating them as black boxes. At As'adiyah Islamic University, the pedagogical approach emphasizes understanding the astronomical principles first through manual calculation and traditional measurement techniques before introducing digital tools, thereby ensuring that technology serves to enhance rather than replace genuine astronomical literacy. This sequenced approach helps students appreciate how modern technologies implement traditional astronomical knowledge while developing critical evaluation skills necessary for assessing technological accuracy and reliability.

Pedagogical Implementation of Qibla Measurement Activities

The practical implementation of qibla direction measurement activities at As'adiyah Islamic University follows a carefully structured pedagogical sequence designed to build student competency progressively from foundational concepts to advanced applications. The instructional approach begins with theoretical preparation, where students study the geographical and astronomical foundations of qibla determination, including coordinate systems, spherical geometry, and the mathematical relationships governing directional calculations. According to Mujab (2020), effective astronomical education requires explicit attention to prerequisite knowledge and conceptual scaffolding, as students often lack the spatial reasoning and geometric intuition necessary for astronomical problem-solving. The preparatory phase therefore includes specific activities designed to develop spatial visualization skills, such as working with globe models, constructing coordinate systems, and tracing great circle routes. This foundational work ensures that students possess the conceptual tools necessary for meaningful engagement with hands-on qibla measurement activities.

Following theoretical preparation, students engage in manual qibla direction calculations using the geographical coordinates of Sengkang and Mecca, working through the spherical trigonometric formulas step-by-step to derive the qibla azimuth. This calculation phase serves multiple pedagogical purposes: it reinforces mathematical skills, develops procedural fluency with astronomical calculations, and provides students with a predicted qibla direction against which they can later compare their measurement results. Jayusman and Shavab (2020) emphasize the importance of having students perform calculations manually before using computational tools, as the manual process reveals the logical structure and mathematical relationships that remain hidden when calculations are automated. Students work collaboratively in small groups during the calculation phase, discussing their approaches, comparing results, and troubleshooting discrepancies. This collaborative problem-solving mirrors authentic astronomical practice while providing peer learning opportunities and reducing individual anxiety about mathematical performance.

The hands-on measurement phase represents the experiential core of the qibla direction learning sequence, where students physically measure the qibla direction using various instruments and techniques. Students learn to use traditional instruments such as magnetic compasses, taking into account magnetic declination corrections necessary for converting magnetic bearings to true bearings. They also employ solar observation methods, tracking shadow movements during specific times of day to determine cardinal directions and subsequently calculate qibla azimuth from true north. Sakirman (2021) notes that the physical act of making measurements, recording observations, and analyzing data engages students in authentic scientific practice while developing important procedural skills and attention to measurement precision. The measurement activities occur in outdoor settings where students can observe actual celestial phenomena and terrestrial landmarks, connecting abstract astronomical concepts with concrete physical reality. This direct sensory engagement with the subject matter creates memorable learning experiences that enhance retention and understanding.

The culminating phase of the pedagogical sequence involves critical analysis and reflection, where students compare their calculated and measured qibla directions, account for discrepancies, evaluate measurement uncertainties, and reflect on the learning process. This analytical work develops crucial scientific thinking skills including error analysis, uncertainty quantification, and critical evaluation of measurement methodologies. According to Kolb and Kolb (2023), the reflection phase proves essential for transforming concrete experience into conceptual learning, as it requires students to abstract general principles from specific instances and articulate their developing understanding. Students prepare written reports documenting their calculation methods, measurement procedures, results, and analysis, thereby developing scientific communication skills alongside astronomical competency. Group presentations allow students to share their findings with peers,

comparing approaches and learning from others' experiences. This reflection and synthesis phase consolidates learning while helping students recognize the broader significance of their qibla direction work for astronomical literacy and religious practice.

Learning Outcomes and Competency Development

The educational outcomes observed through qibla direction measurement activities at As'adiyah Islamic University demonstrate significant enhancement of students' astronomical literacy across multiple dimensions of knowledge and skill. Students develop substantially improved understanding of fundamental astronomical concepts including the celestial sphere, coordinate systems, azimuth and altitude, and the relationship between terrestrial and celestial positions. These conceptual gains prove durable and transferable, as students subsequently demonstrate enhanced performance in other astronomical topics requiring similar spatial reasoning and geometric conceptualization. Izzuddin (2022) reports that hands-on astronomical activities produce learning gains superior to traditional lecture-based instruction, particularly for concepts involving three-dimensional spatial relationships and dynamic celestial phenomena. The qibla measurement activities thus serve as a catalyst for broader astronomical learning, establishing conceptual foundations and cognitive skills that support continued development of astronomical literacy throughout students' educational careers.

Beyond conceptual understanding, students develop important procedural and technical competencies through qibla direction measurement work, including proficiency with measurement instruments, systematic observation techniques, data recording and analysis, and mathematical calculation procedures. These technical skills possess immediate practical value for students' religious lives, as graduates can accurately determine qibla direction for themselves and provide this service to their communities. Hambali (2022) emphasizes that Islamic universities bear responsibility for producing graduates who can serve as religious authorities in their communities, including providing expertise in astronomical matters affecting religious practice. The technical competencies developed through qibla measurement activities directly support this vocational preparation, equipping students with practical skills they will utilize throughout their professional lives. Furthermore, the measurement and calculation skills developed through qibla work prove transferable to other astronomical applications including prayer time calculation, Islamic calendar determination, and eclipse prediction.

The qibla direction measurement activities also foster development of broader cognitive and metacognitive capabilities that extend beyond domain-specific astronomical knowledge. Students develop enhanced spatial reasoning abilities, improved mathematical problem-solving skills, and strengthened capacity for systematic observation and data interpretation. The collaborative nature of measurement activities supports development of teamwork, communication, and collaborative problem-solving skills highly valued in

contemporary professional contexts. According to Jayusman and Shavab (2020), well-designed experiential learning activities promote development of higher-order thinking skills including analysis, synthesis, and evaluation, as students must critically engage with concepts and procedures rather than passively receiving information. Students working on qibla measurement projects demonstrate enhanced metacognitive awareness, becoming more conscious of their own thinking processes, learning strategies, and knowledge gaps. This metacognitive development supports students' capacity for self-directed learning and professional development beyond their formal education.

Perhaps most significantly, the qibla direction measurement activities strengthen students' sense of connection between Islamic religious tradition and scientific inquiry, helping them recognize that faith and reason need not conflict but can mutually reinforce one another. Students come to appreciate Islamic astronomy as a sophisticated intellectual tradition that contributed significantly to global scientific development while simultaneously serving important religious functions. This integrated understanding proves particularly valuable in contemporary contexts where Muslim students often encounter artificial dichotomies between religious and scientific worldviews. Kamaluddin et al. (2021) argue that Islamic educational institutions bear special responsibility for demonstrating the compatibility and complementarity of religious commitment and scientific rationality. The qibla measurement activities at As'adiyah Islamic University effectively model this integration, showing students how astronomical science serves religious devotion while religious questions stimulate scientific investigation. This holistic educational outcome—strengthening both astronomical competency and religious identity—represents the ultimate success of the pedagogical intervention (Mufida Nur Tsuraya, Muhammad Fadhil Afif, Muthia Mufida Anwar, Syamsuddin Semmang, Nurfaika Nurfaika, Muhsyanur Muhsyanur, n.d.).

Challenges, Limitations, and Future Directions

Despite the demonstrated effectiveness of qibla direction measurement activities for developing astronomical literacy, several significant challenges and limitations affect implementation and outcomes. Students enter the program with highly variable mathematical backgrounds, creating difficulties in pacing instruction appropriately for all learners. Some students struggle with the trigonometric calculations required for qibla determination, necessitating additional mathematical support and review before they can meaningfully engage with the astronomical content. According to Mujab (2020), mathematical anxiety and deficiency represent substantial barriers to astronomical learning for many students, requiring careful pedagogical attention to mathematical prerequisites and scaffolding. The instructional team has responded by developing supplementary mathematical review materials and offering additional tutorial support for students

requiring mathematical reinforcement. However, the heterogeneity of student mathematical preparation remains an ongoing instructional challenge requiring continued pedagogical innovation and differentiated instruction.

Practical constraints including limited equipment availability, weather dependencies, and time limitations also affect the scope and quality of measurement activities. The university's instrument inventory includes a modest number of compasses, theodolites, and GPS receivers, requiring students to work in groups and rotate through measurement stations rather than each student having individual access to all instruments. Weather conditions significantly affect observation-based measurement activities, as overcast skies prevent solar observation techniques while heavy rainfall makes outdoor measurement impractical. Azhari (2021) notes that astronomy education inherently faces logistical challenges related to weather dependency and the need for outdoor observation opportunities, requiring flexible scheduling and alternative activities for unfavorable conditions. Time constraints within the academic calendar limit the number of measurement sessions that can be conducted, preventing the iterative refinement of measurement techniques that would ideally support deeper learning. These practical limitations necessitate careful planning and efficient use of available resources while acknowledging that optimal learning conditions cannot always be achieved.

Assessment of astronomical literacy development presents another significant challenge, as authentic astronomical competency encompasses conceptual understanding, procedural skills, and practical application capabilities that prove difficult to evaluate through conventional examination methods. Traditional written examinations can assess conceptual knowledge and computational procedures but struggle to evaluate practical measurement skills, observational competencies, or the ability to troubleshoot real-world problems. According to Hambali (2022), effective assessment of astronomical literacy requires multiple evaluation methods including practical demonstrations, project work, oral presentations, and written examinations. The instructional team employs a portfolio-based assessment approach that includes students' calculation worksheets, measurement data records, analysis reports, and reflective essays. While this comprehensive assessment approach provides richer information about student learning than traditional examinations alone, it also requires substantially more instructor time and effort for evaluation. Developing efficient yet authentic assessment methods remains an ongoing challenge in the program.

Looking toward future development of the program, several promising directions emerge from reflection on current practice and consideration of emerging opportunities. Expansion of the measurement activities to include other astronomical calculations such as prayer times and Islamic calendar determination would strengthen connections between different domains of Islamic astronomy while providing additional contexts for applying astronomical literacy. Integration of digital technologies including smartphone applications,

online calculation tools, and virtual reality simulations could enhance learning while preparing students for contemporary technological contexts. Sakirman (2021) suggests that thoughtful integration of traditional and modern methods, manual and digital techniques, represents the most promising approach for contemporary Islamic astronomical education. Development of community engagement components where students provide qibla direction services to local mosques and Islamic institutions would enhance the practical relevance and social value of students' learning while serving genuine community needs. These future directions promise to strengthen and extend the educational impact of qibla direction measurement activities while maintaining the core pedagogical principles that have proven effective.

CONCLUSION

The educational implementation of qibla direction measurement at As'adiyah Islamic University Sengkang demonstrates significant potential for strengthening student astronomical literacy through experiential learning that meaningfully integrates theoretical knowledge with practical application. The pedagogical approach, grounded in experiential learning principles and responsive to Islamic educational contexts, successfully develops student competency across multiple dimensions including conceptual understanding, technical skills, scientific reasoning, and appreciation of Islamic astronomical heritage. Students emerge from the qibla measurement activities with enhanced spatial reasoning, improved mathematical problem-solving abilities, and practical competencies directly applicable to their religious lives and community service. The integration of traditional Islamic astronomical methods with contemporary measurement technologies provides students with both historical perspective and modern relevance. While challenges including variable student preparation, resource limitations, and assessment complexities persist, the demonstrated learning outcomes justify continued investment in and refinement of hands-on astronomical education. As Islamic universities continue to navigate the relationship between traditional religious scholarship and contemporary scientific education, qibla direction measurement activities exemplify how authentic integration can be achieved, serving both religious and scientific educational goals while preparing students for meaningful engagement with Islamic astronomy in contemporary contexts.

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