INDONESIAN JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION
06 (3) (2023) 416-429
https://ejournal.radenintan.ac.id/index.php/IJSME/index
E-ISSN: 2615-8639
DOI: 10.24042/ijsme.v6i3.19790
November 2023

Mathematical framework for accurate prayer times: Insights from the *bencet* tradition

Lukman Hakim Muhaimin, Yaya S. Kusumah*, Dadang Juandi, Agus Hendriyanto, Sani Sahara

Department of Mathematics Education, Faculty of Mathematics and Natural Science Education, Universitas Pendidikan Indonesia, Indonesia

**Corresponding author:* yskusumah@upi.edu

Article history:

Submitted: May 15, 2023
Accepted: October 20, 2023
Published: November 30, 2023

Keywords:

bencet, ethnographic, ethnomathematics, mathematics education, prayer times

ABSTRACT

Mathematics is fundamental in structuring religious practices, especially in determining prayer times. This study explores the mathematical concepts embedded in the traditional *bencet* tool used by communities to calculate prayer times accurately. Using a qualitative ethnographic approach, the research examines both the use and crafting of *bencet* through observations, interviews, and documentation. Based on the Miles and Huberman model, data analysis reveals that the *bencet tongkat* unconsciously incorporates mathematical concepts such as parallel lines, measurements, and planar surfaces. Similarly, the *bencet garis* reflects understanding parallel and perpendicular lines, circular constructions for 90° angles, and precise measurements. The findings underscore the deep interconnection between mathematical principles and cultural traditions. This study concludes that the *bencet* tool represents an untapped resource for ethnomathematics research. The implications highlight the potential of ethnomathematics as an innovative approach to mathematics education, integrating cultural heritage into learning.

Kerangka matematika untuk ketepatan waktu salat: Perspektif dari tradisi Bencet

Kata Kunci:

bencet, etnografi, etnomatematika, pendidikan matematika, waktu shalat

ABSTRAK

Matematika memiliki peran fundamental dalam mengatur praktik keagamaan, terutama dalam penentuan waktu salat. Penelitian ini mengeksplorasi konsep matematis yang terkandung dalam alat tradisional bencet, yang digunakan masyarakat untuk menghitung waktu salat secara akurat. Dengan pendekatan etnografi kualitatif, penelitian ini mengkaji penggunaan dan pembuatan bencet melalui observasi, wawancara, dan dokumentasi. Analisis data menggunakan model Miles dan Huberman menunjukkan bahwa bencet tongkat secara tidak sadar menerapkan konsep matematika seperti garis sejajar, pengukuran, dan bidang datar. Demikian pula, bencet garis merefleksikan pemahaman tentang garis sejajar, garis tegak lurus, penggunaan lingkaran untuk sudut 90°, serta pengukuran yang presisi. Temuan ini menyoroti keterkaitan mendalam antara prinsip matematika dan tradisi budaya. Penelitian ini menyimpulkan bahwa bencet merupakan sumber yang belum banyak dieksplorasi dalam studi etnomatematika. Implikasi penelitian ini menekankan potensi etnomatematika sebagai pendekatan inovatif dalam pendidikan matematika dengan mengintegrasikan warisan budaya ke dalam pembelajaran.

Contribution to the Literature

This research contributes to:

- Pioneering the study of *bencet* in ethnomathematics, revealing how concepts like parallel and perpendicular lines and measurement are unconsciously applied in cultural practices.
- Highlighting *bencet* as a meaningful resource for contextual mathematics learning, bridging cultural wisdom and formal education.
- Emphasizing integrating local wisdom into education to enhance student engagement while preserving cultural values.

1. INTRODUCTION

Recognizing that the connection between mathematics and culture is not a new concept is crucial. Historically, civilizations have used mathematical concepts to describe and celebrate cultural practices [1]-[3]. In this context, ethnomathematics emerged as a research method that opened a window into the complexity of these relationships [2], [4], [5]. Ethnomathematics is not merely about mapping the application of mathematics to cultural practices. Rather, it broadens its scope to explore cultural aspects involving mathematical concepts [6]-[9]. At its core, it delves into understanding how culture and mathematics intertwine and impact each other. Research in ethnomathematics is not limited to past cultures but extends to emerging or contemporary cultures. Consequently, studies on ethnomathematics will remain relevant as cultures continue to evolve alongside human life.

In the ever-growing field of interdisciplinary studies, the convergence of mathematics and cultural practices provides a unique avenue for exploration. This scientific endeavor has sparked a fascinating journey into ethnomathematics, where a complex tapestry of cultural traditions is revealed through the lens of precise mathematical frameworks. This captivating journey aligns with the research aims, seeking to unravel and interpret the mathematical principles embedded in various cultural practices. The intersection between mathematics and cultural practices has long fascinated academics, offering fertile ground for uncovering mysteries embedded in the structures of diverse societies [7], [10]. Civil [11] revealed that ethnomathematics, as a developing research field, seeks to understand and interpret mathematical principles embedded in cultural practices. This research is evidence of growing interest in bridging the gap between mathematical rigor and the cultural intricacies that define human society [12].

Prahmana and D'Ambrosio [13] provide an etymological explanation of ethnomathematics, deriving from three Greek root words: "*ethno*," meaning a natural or sociocultural group; "*mathema*," meaning explaining or learning; and "*thic*," meaning method, art, or technique. Thus, ethnomathematics can be defined as a program that examines the patterns in which members of a particular culture (*ethno*) have historically developed the ability to measure, calculate, conclude, compare, and classify techniques and ideas (*mathema*), enabling them to model the environment in both natural and social contexts to explain and understand phenomena (*tics*). Cimen [14] aligns with this definition, describing ethnomathematics as mathematics practiced among identifiable cultural groups, such as ethno-national communities, working classes, children of specific age groups, and professional classes.

Indonesian researchers, such as Muhtadi *et al.* [15] and Prahmana [16], Prahmana and D'Ambrosio [17] further contribute to this understanding by asserting that ethnomathematics refers to the application of mathematics within a cultural context. This perspective aligns with the broader conceptualization of ethnomathematics as a dynamic and evolving field that examines mathematical practices within distinct cultural groups, emphasizing the integration of mathematics and culture in various societal contexts. Such an approach highlights the role of cultural heritage in shaping mathematical understanding and its relevance in education.

This research aims to explicitly connect the cultural artifact known as the *bencet* with the field of ethnomathematics by exploring its mathematical underpinnings. The *bencet*, a sundial, plays a traditional role in determining prayer times [18]. The term *bencet* encapsulates a mathematical understanding intricately tied to the Earth's 24-hour rotation, influencing the variations in day and night across different global locations. The geographical positioning of a place, whether in the East or West, results in distinct prayer times due to the Earth's rotation, with locations in the East experiencing earlier times than those in the West. Therefore, determining prayer times becomes a mathematical consideration influenced by the sun's movement.

The use of *bencet* is specifically linked to calculating the midday and Asr prayer times, relying on the sunlight or shadow it produces. This application of *bencet* underscores the intersection between mathematical concepts, cultural practices, and religious observances, providing a tangible example of ethnomathematics in action within Islamic traditions. The research delves into the cultural and mathematical intricacies embedded in the utilization of *bencet*, contributing to a deeper understanding of how mathematical principles are interwoven into everyday practices and artifacts within specific cultural contexts.

The selection of *bencet* as the focus of this inquiry adds a significant layer of cultural specificity to the exploration. Rooted in the cultural fabric of a specific community, *bencet* manifests as a unique approach to timekeeping, intricately intertwined with religious rituals, community bonds, and a meticulous commitment to punctuality. The context for determining prayer times becomes a rich mosaic of beliefs, rituals, and social structures [19]. By carefully examining the *bencet*, this research aims to uncover the mathematical algorithms implicitly embedded in its construction and the precise determination of prayer times. The interplay of cultural and mathematical elements within this tool offers an intriguing case study, allowing researchers to discern the underlying patterns and principles that govern the accurate calculation of prayer times within this cultural context. By exploring the relationship between cultural specificity and mathematical algorithms within the context of *bencet*, this research seeks to contribute to understanding ethnomathematics and the broader discourse on how mathematical concepts are woven into diverse cultural practices.

Previous ethnomathematics studies have revealed mathematical concepts embedded in Indonesian cultures [20]-[23]. Literature research indicates significant growth in ethnomathematics studies in recent decades, particularly in mathematics teaching within the school environment. Most ethnomathematics research has been conducted by Indonesian researchers, who consistently contribute to understanding mathematics in cultural contexts [7]. However, despite the abundant research in this field, no specific study has explored *bencet* or similar phenomena within an ethnomathematics framework [7], [24]. This gap in the literature highlights the need for further exploration of specific cultural artifacts, such as *bencet*, within the ethnomathematics framework, to better understand the complex intersections between mathematical concepts and culturally specific tools or practices. By addressing this gap, the current research aims to contribute to the broader field of ethnomathematics and enhance pedagogical approaches that integrate cultural nuances into mathematics education.

Exploring ethnomathematics within the context of *bencet* introduces a compelling dimension to the field, considering the unique role *bencet* plays in the daily lives of individuals, particularly within specific cultural contexts. This research aims to fill a significant gap in the existing literature by providing the first dedicated investigation into the ethnomathematics of *bencet*. Despite its undeniable influence on daily activities, there has been a noticeable absence of ethnomathematics studies explicitly examining the intricacies of *bencet*. This gap underscores the urgency and importance of conducting a comprehensive exploration that recognizes *bencet* and investigates how it uniquely contributes to the expression of mathematical concepts within cultural practices. By addressing this void, the research not only broadens the horizons of ethnomathematics but also establishes a foundational understanding of the intricate relationship between mathematics and culture, enriching the overall discourse on the subject.

As researchers embark on this ethnomathematical journey, it is essential to acknowledge the broader implications of the investigations undertaken. Beyond academic curiosity, the insights gained from this research hold practical significance for communities that use *bencet*. By explaining the mathematical precision behind accurate prayer times, the research aspires to contribute not only to academic discourse but also to the practical improvement of religious practices in a culturally sensitive manner. This study is evidence of the dynamic interconnections that define human society, reflecting a commitment to uncovering the complexities of cultural practices and recognizing the symbiotic relationship between tradition and precision.

2. METHOD

This research explores the mathematical concepts embedded in *bencet*, focusing on two types: those manifested as artifacts and those represented as ideas. The research process followed three main steps: data analysis before fieldwork, data analysis during fieldwork, and overall data analysis [25]. A qualitative research design with an ethnographic approach was employed. This approach enables the researcher to understand how mathematical concepts are reflected in the culture [25]. The data collection techniques adhered to ethnographic principles, which included observation, interviews, documentation, and field notes with original ethnographic descriptions. Before conducting interviews, the researcher ensured adherence to research ethics and emphasized voluntary participation. Two individuals with extensive knowledge of *bencet* were selected, providing valuable insights into how mathematical concepts are integrated into the culture. Additionally, observations were conducted primarily on *bencet* artifacts still in use, particularly at the Al Muayyad Mosque in Surakarta. Through this approach, the study identifies the mathematical concepts found in the artifacts and examines how mathematical ideas are reflected in the daily culture of the people who use *bencet*.

Data analysis was carried out at multiple stages, including during and after data collection. The primary method used was in-depth interviews, with the researcher analyzing the participants' responses as the interviews progressed [26]. When responses lacked sufficient depth for a thorough understanding, additional questions were posed until data credibility and saturation were achieved. The researcher followed the data analysis model proposed by Miles *et al.* [27], which involves three key activities: data reduction, data display, and drawing/verifying conclusions. The analysis steps are illustrated in Figure 1. This approach ensured that the findings were systematically organized and interpreted. Furthermore, cross-checking with other data sources was conducted to enhance the validity of the results.

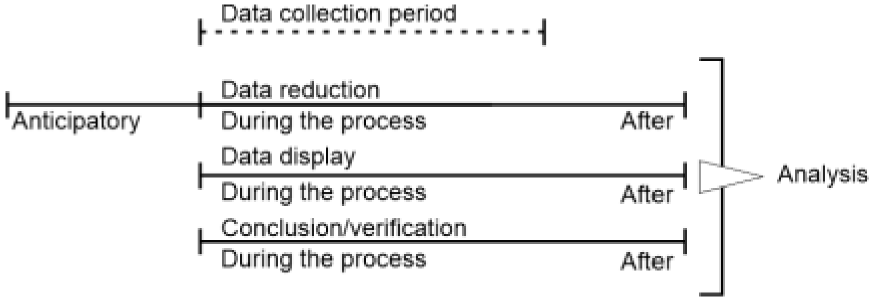


Figure 1. Model of Data Analysis [27]

Examining Figure Y presented earlier, the researcher actively engaged in data reduction following the data collection phase. This process involves making decisions—sometimes unconsciously—regarding selecting a conceptual framework, research questions, research sites, and data collection methods. Miles *et al.* [27] describe qualitative data analysis as an ongoing, interactive process until data saturation is achieved. The interactive model of data analysis is illustrated in Figure 2.

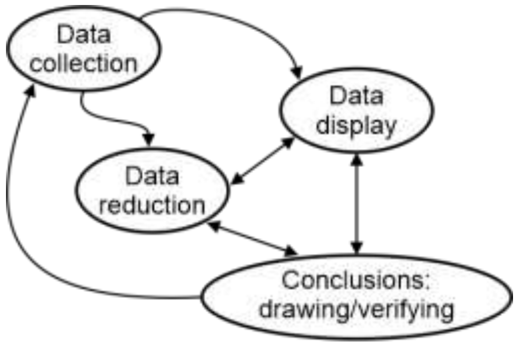


Figure 2. Interactive Model in Data Analysis [27]

3. RESULT AND DISCUSSION

3.1 Bencet Tongkat

Researchers categorize the *bencet tongkat* as a conceptual innovation because the stick-banging technique can be applied in various settings. The idea of *bencet* originated from a hadith narrated by Jabir Ibn 'Abdullah:

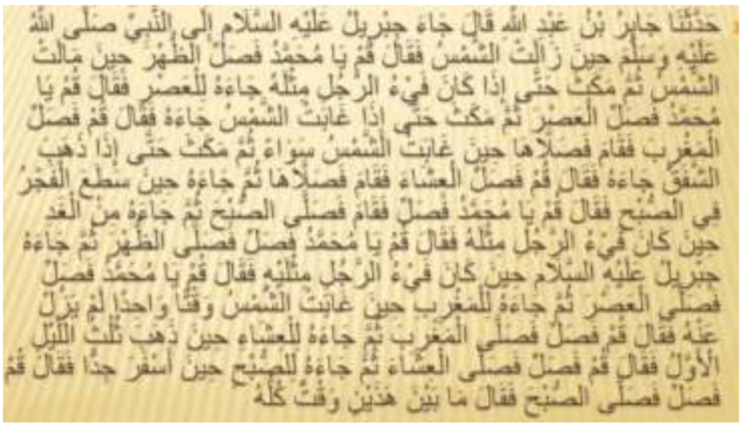

حدثنا جابر بن عبد الله قال جاء جبريل عليه السلام إلى النبي صلى الله
عليه وسلم حين زالت الشمس فقال قم يا محمد فصل الظهر حين مالت
الشمس ثم مكث حتى إذا كان فيء الرجل مثله جاءه للعصر فقال قم يا
محمد فصل العصر ثم مكث حتى إذا غابت الشمس جاءه فقال قم فصل
المغرب فقام فصلاها حين غابت الشمس سواء ثم مكث حتى إذا ذهب
الشفق جاءه فقال قم فصل العشاء فقام فصلاها ثم جاءه حين سطع الفجر
في الصبح فقال قم يا محمد فصل فقام فصلى الصبح ثم جاءه من الغد
حين كان فيء الرجل مثله فقال قم يا محمد فصل فصلى الظهر ثم جاءه
جبريل عليه السلام حين كان فيء الرجل مثليه فقال قم يا محمد فصل
فصلى العصر ثم جاءه للمغرب حين غابت الشمس وقتا واحدا لم يزل
عنه فقال قم فصل فصلى المغرب ثم جاءه للعشاء حين ذهب ثلث الليل
الأول فقال قم فصل فصلى العشاء ثم جاءه للصبح حين أسفر جدا فقال قم
فصل فصلى الصبح فقال ما بين هذين وقت كله

Figure 3. Hadith Narrated by Jabir Ibn 'Abdullah

Meaning: *The Hadith narrated by Jabir ibn 'Abdullah states that Jibril (Alaihissalam) came to the Prophet (peace be upon him) and said: "Get up and pray." So the Prophet prayed Dhuhr when the sun had passed its zenith. Then Jibril came at Asr time* *and said: "Get up and pray." The Prophet then performed the Asr prayer when the sun's shadow equaled the object's length. Later, Jibril came to Maghrib and said: "Get up and pray." The Prophet prayed Maghrib when the sun had set. Then Jibril came at Isha's time and said: "Get up and pray." The Prophet performed the Isha prayer when the red twilight had disappeared. Jibril then came at Fajr (dawn) and said: "Get up and pray." The Prophet prayed Fajr when the true dawn had risen. The next day, Jibril returned at Dhuhr time and said: "Get up and pray." This time, the Prophet prayed Dhuhr when the shadow of an object had lengthened. Jibril came at Asr when the sun's shadow was twice the object's length. At Maghrib, Jibril came at the same time as the previous day. For Isha', Jibril arrived when half or a third of the night had passed, and the Prophet prayed the Isha' prayer accordingly. Finally, Jibril came again at Fajr when the true dawn had risen and said: "Get up and pray the morning prayer." Afterward, Jibril said: "The time between these two instances marks the valid period for each prayer."*

The Javanese people developed a prayer time marker known as the *bencet tongkat* based on the Hadith. This stick serves a specific function in determining two prayer times: Dhuhur and Asr. The time for Dhuhur is indicated by the sun's position when an object's shadow shifts or leans towards the East. This demonstrates that the *bencet tongkat* relies on natural phenomena, particularly the sun's movement, as a temporal reference. Additionally, the concept of special time is also present in this context. Special time refers to when an object casts no shadow at all. This understanding adds a layer of complexity to determining prayer times and reflects the depth of public knowledge regarding astronomical phenomena.

Figure 4. Illustration of Interview Excerpts

The question is: What is the concept of ethnomathematics embedded in it? Before delving deeper into ethnomathematics, it is important to examine the following interview excerpt and refer to Figure 4, which provides a visual representation to support the discussion.

Researcher	:	Earlier, we explained the special moment when an object casts no shadow. To determine the time of *Istiwa*, the object must be positioned upright on a flat surface. But how do we ensure an object stands upright?
Respondent	:	Before the idea of striking the *bencet tongkat*, we often used our bodies to observe the time of *Istiwa*. When we stand upright, and our shadow appears directly beneath us, that marks the special moment. Similarly, when we place a stick upright, we compare its shadow with our own to confirm that it also disappears.

The illustration in Figure 4, based on the resource person's explanation, demonstrates the application of mathematical concepts, even though the individuals involved may be unaware of it. Specifically, the concept being applied is the parallelism of two lines. In mathematics, parallel lines are defined as two lines on a plane that never intersect, regardless of how far they are extended. Geometrically, parallel lines will never meet because they share the same slope (gradient).

The discovery of this concept through the arrangement of sticks is particularly intriguing, as the creators unknowingly implemented mathematical principles by positioning the sticks parallel. This concept of parallelism directly applies to geometry, particularly in the study of parallel lines. Thus, this case exemplifies ethnomathematics, where mathematical concepts are naturally embedded in cultural practices without explicit awareness.

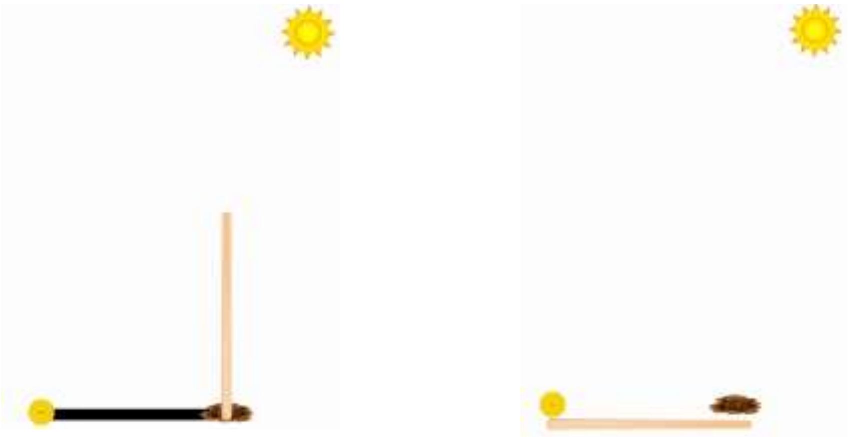


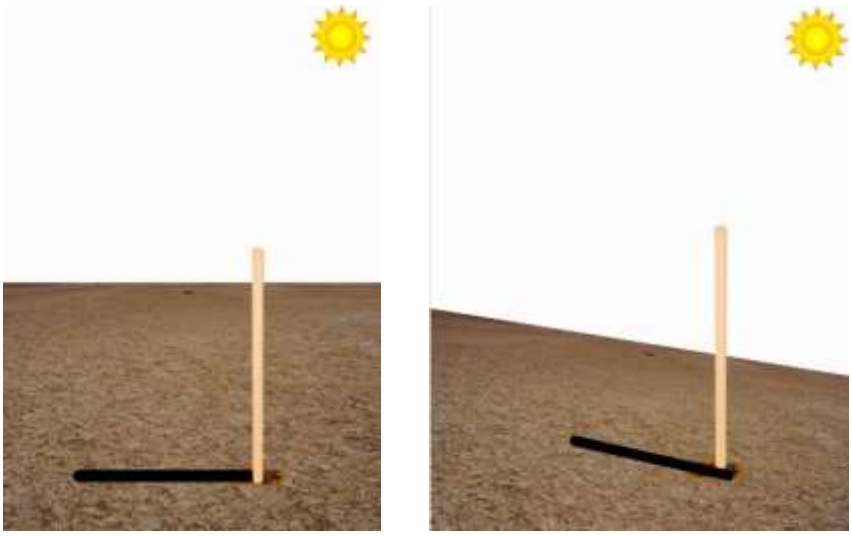
Figure 5. Illustration of the Measurement Process for Determining the Time of Asr Prayers

The approach to measuring Asr prayer times using a *bencet tongkat* illustrates the integration of mathematical concepts into the daily practices of the community. Two methods are used to determine the timing of the Asr prayer: one based on the shadow of an object being equal in length to the object itself and the other based on the shadow being twice the object's length. These methods highlight the role of mathematics in identifying the precise moment of worship.

This traditional method of measuring Asr prayer times does not rely on modern measuring instruments such as rulers or meters. Instead, the community considers the stick's length (*bencet tongkat*) as a unit of measurement, regardless of its specific dimensions. To determine the time for Asr prayer, they either use a stick specifically made to identify the *Istiwa* (solar noon) or create a new one by marking a reference line at the top of the shadow. The measurement involves placing the stick in a designated hole, ensuring the unembedded base aligns with the previous position. The tip of the stick is then directed toward the dividing line created earlier. If the shadow's length is equal to or greater than the stick's length, they conclude that the time for Asr prayer has arrived. An illustration of this process is shown in Figure 5. This practice demonstrates how people unfamiliar with modern measuring tools apply mathematical reasoning daily. Although simple, this method reflects key mathematical principles in time measurement, showcasing creativity and local wisdom in integrating mathematics into everyday life.

Furthermore, the community's awareness of the importance of using the *bencet tongkat* on a flat surface highlights mathematical thinking, which can be categorized as ethnomathematics. The process of determining prayer times, particularly for Dhuhur and Asr, underscores the significance of a level surface in ensuring accuracy. First, their awareness of the need for a flat surface when determining Asr prayer time demonstrates an understanding of precision. They recognize that if the stick is placed on an uneven surface, the accuracy of the shadow's length may be compromised, leading to incorrect timing.

Conversely, in special circumstances, they understand that the condition of the surface does not affect the shadow's position as long as the stick is held perpendicular to the sun. This insight reflects a fundamental mathematical concept. Based on these observations, the conclusion is that creating a flat surface is essential for accuracy, making this practice a clear example of ethnomathematics. Ethnomathematics refers to how specific cultures apply mathematical concepts in their daily lives. In this context, the emphasis on a flat surface as a crucial factor in measurement reflects a deep-rooted mathematical understanding embedded in the community's cultural traditions.



(a) (b)

Figure 6. Illustration of Bumps on a Flat Plane (a) An Inclined Plane and (b) Under the Same Time and Conditions

3.2 Bencet Garis

Bencet, in the form of artifacts, as explained in the previous section, refers to specialized objects used for a specific purpose—in this case, determining the time of *Istiwa* at the Al Muayyad Mosque in Surakarta. This artifact has distinct characteristics, featuring a simple design, and is found only in certain locations, such as mosques. This type of time-measuring device in a mosque indicates that the tradition of using such instruments is still preserved, particularly in religious contexts.

A small hole in the roof of the building, accompanied by a line below it, is an essential part of this artifact. Determining *Istiwa* time involves aligning the sun's rays at noon with the center of the line. In other words, this artifact provides a clear visual cue indicating the arrival of this special time. Notably, this type of *bencet* serves a singular function—determining a specific moment in time. Its presence in mosques and its association with religious practices highlight how this traditional tool continues to be utilized and preserved, reflecting cultural values and local wisdom.

The primary advantage of this *bencet garis* lies in its consistency. It can be used daily to determine special times, creating the impression of a "perpetual clock." Its regularity and accuracy in determining *Istiwa*'s time make it a reliable tool for the local community. As illustrated in Figure 7, the round rays of sunlight move from East to West, approaching the line, signifying the sun's movement. When the circular ray aligns precisely with the middle of the line, it marks the special time.

Additionally, this ray moves east to West and gradually shifts from north to south over time due to the moon's progression. This phenomenon creates a continuous cycle, reinforcing the artifact's role in timekeeping. The true north-south line, as depicted in Figure 7, serves as a visual guide for understanding the movement of sunlight during this special time.

Figure 7. *Bencet Garis* at the Al Muayyad Mosque in Surakarta

Regardless of the inventor's expertise, the interview results indicate that the process of making a *bencet garis* reflects the concept of ethnomathematics. The process begins by creating a circular hole in the roof. A weighted rope is then suspended from the hole to identify the center point on the floor. Sunlight passing through the hole is observed in the morning and afternoon to mark two points, establishing a true east-west line. These points are connected using a rope to form a straight line. A parallel line is drawn if the line does not pass through the center point. A paper circle is folded into quarters to determine the true north-south line. One fold is aligned with the east-west line, while the perpendicular fold represents the north-south line. These steps are illustrated in Figure 8, where A represents the center point, B is the morning ray point, and C is the noon ray point.

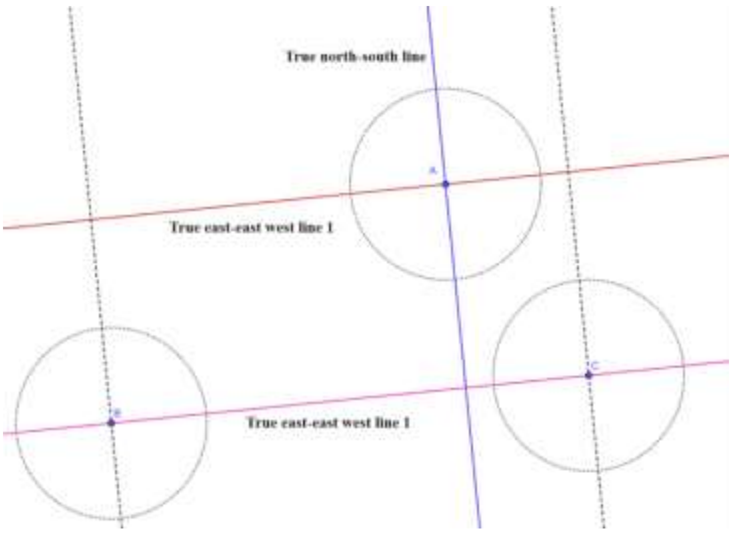


Figure 8. The Illustration of the Process of Making *Bencet Garis*

Making *bencet garis* involves numerous mathematical concepts, particularly geometric principles. Researchers have translated the terms used in the stages above into mathematical language, such as parallel, perpendicular, and center points. However, during interviews, the interviewees simply referred to these as lines without distinguishing whether they were parallel or perpendicular.

Several ethnomathematical concepts identified in making *bencet garis* include parallel and perpendicular lines, constructing perpendicular lines, and measurements in determining parallel lines. Although the source did not explicitly mention these terms, parallel and perpendicular lines are evident when creating the main lines. Constructing a true east-west line and a true north-south line requires understanding the relative relationships between these lines. This concept can be applied in mathematics learning, particularly in the geometry subtopic of line properties. In mathematics, a perpendicular line is defined as two lines that meet to form congruent adjacent angles, which means they form right angles (90°). The interviewees did not mention "right angle" or "90-degree angle." Still, their method of using a circular piece of paper and dividing it into four parts corresponds to the concept of a circle (360°) divided into four equal parts (90° each). This concept is applicable in mathematics learning, particularly in geometry and trigonometry. Figure 5 illustrates that the process is not arbitrary when making parallel lines (true east-west line 2). The designers of *bencet garis* follow a sequence that aligns with the mathematical definition of parallel lines. They begin by creating two perpendicular lines passing through points B and C. Then, new points are placed on both lines at equal distances so they pass through the center point. This concept is relevant in mathematics learning, particularly in measurement topics. Thus, it is evident that *bencet*, as a cultural heritage artifact, incorporates ethnomathematical principles.

The two forms of *bencet* described previously measure time and reflect the continuity of traditions and cultural values inherent in a society. The manufacturing process and the mathematical concepts involved in *bencet* have been passed down through generations, highlighting cultural values embedded in mathematical practice [28]. Using *bencet* as a tool for determining time is not only a manifestation of inherited mathematical practices but also plays a role in maintaining and developing cultural values. Communities that maintain the effective use of *bencet* continue their traditions and the understanding of mathematical concepts in everyday life. Thus, the *bencet* is a tool and a symbol of cultural continuity and community identity. The importance of understanding the contextual context of mathematics in culture and society becomes apparent through *bencet*. By measuring time and determining the sun's position, mathematical concepts become meaningful in everyday life, proving that ethnomathematics is theoretical and relevant in social and cultural reality.

Traditional approaches to teaching mathematics often feel rigid and disconnected from students' social and cultural contexts [29]. Mathematics is traditionally taught through a formal approach that tends to be normative and dogmatic, making the learning experience less meaningful for students. In response to this issue, ethnomathematics has emerged as an innovative solution to enhance mathematics education in formal settings. Numerous studies support the idea that integrating an ethnomathematical approach allows students to relate mathematical knowledge to their daily lives, making learning more meaningful [7]. By incorporating cultural and social aspects into mathematics instruction, ethnomathematics fosters student engagement and creativity in understanding and solving mathematical problems. This approach helps students recognize the role of mathematics in everyday life, making the subject more relevant and accessible.

The integration of ethnomathematics into mathematics education is based on the understanding that mathematics is not an isolated discipline but an expression of human culture and thought [30]. Viewing mathematics as an integral part of culture allows students to feel more connected and engaged in learning. Consequently, mathematics education should explore and incorporate the sociocultural contexts surrounding students [31]. By contextualizing mathematical learning within students' cultural environments, educators can create more relevant lessons that address students' internal values and broader mathematical knowledge [7]. Immersing students in their cultural contexts makes mathematics education more inclusive and applicable to real-world problem-solving. Ultimately, ethnomathematics bridges the gap between abstract mathematical concepts and students' experiences, bringing greater meaning and relevance to mathematics learning.

D'Ambrosio [2], Stuart and Robert [32] have played a crucial role in developing ethnomathematics by introducing the trivium curriculum, emphasizing literacy, matheracy, and technocracy. This curriculum is a foundation for ethnomathematics studies and their application in mathematics education. Literacy refers to students' ability to process, write, represent, calculate, and utilize various media in this framework. Matheracy involves interpreting and analyzing symbols and codes to model and solve everyday problems. Technocracy, on the other hand, focuses on students' ability to use and integrate technological tools in daily activities while assessing the reasonableness and contextual relevance of their results [17], [33], [34].

Although the trivium curriculum does not explicitly emphasize cultural elements, it aligns with Gerdes' view [35] that ethnomathematics represents "the mathematics implicit in every practice." This perspective acknowledges that mathematics is not solely a normative and formal discipline but also encompasses cultural dimensions embedded in societal practices. Educators can bridge mathematical concepts with students' real-life experiences by adopting the trivium curriculum, making mathematics more applicable and meaningful [2]. Along with the evolution of ethnomathematics, the Trivium curriculum significantly contributes to articulating the role of mathematics in everyday life through understanding literacy, matheracy, and technocracy [34]. This approach creates a broader foundation for learning mathematics, where students not only master formal mathematical concepts but can also apply them in their cultural context.

Despite its valuable insights, this study is limited in scope, as it primarily explores ethnomathematical aspects without fully examining their integration into school mathematics curricula. The research focuses on the ethnomathematical dimensions related to *bencet*, shedding light on cultural practices and mathematical concepts. However, it does not thoroughly address how these findings can be directly applied in broader educational contexts. Future research should explore the practical implications of ethnomathematical studies and investigate how these insights can be effectively incorporated into mathematics education. By doing so, educators can enhance students' understanding and appreciation of mathematics while making learning more culturally relevant and engaging.

4. CONCLUSION

Bencet, bencet tongkat, and *bencet garis* uniquely determine the times for *Istiwa* and Asr prayers. This study reveals that these traditional practices incorporate the concept of ethnomathematics, where mathematical principles are embedded in cultural activities without explicit recognition. One key finding highlights the importance of a flat surface in determining the time for Asr prayer. The community understands the accuracy and precision of using sticks for this purpose, emphasizing the necessity of a perfectly level surface. This suggests that knowledge of flat planes is essential in this practice.

Mathematical concepts such as parallel and perpendicular lines are unconsciously applied when constructing *bencet garis*. These findings underscore the need for a mathematics teaching approach that is contextual and closely connected to daily life, fostering deeper student engagement and comprehension of mathematical concepts. Integrating cultural contexts into mathematics learning can enhance its effectiveness, making it more meaningful and accessible.

This research also highlights the potential of ethnomathematics as an innovative approach to mathematics education. Incorporating ethnomathematical concepts into the curriculum can make learning more relevant and engaging for students. Future research should explore ethnomathematics within other cultural traditions, develop educational materials that integrate these concepts, and assess the effectiveness of ethnomathematics in formal education. This study offers a deeper understanding of the relationship between mathematics and culture, paving the way for more inclusive and contextually relevant teaching methods.

AUTHOR CONTRIBUTION STATEMENT

LHM conceptualized the research idea, conducted field studies on the *Bencet* tradition, and drafted the initial manuscript. YSK developed the mathematical framework, reviewed the manuscript, and ensured its academic rigor. DJ designed the methodology, conducted data analysis, aligned the study with ethnomathematical principles, and provided editorial feedback. AH integrated cultural perspectives with mathematical concepts, handled data visualization, and prepared figures. SS conducted the literature review, ensured consistency with existing scholarly works, and managed final editing and formatting.

ACKNOWLEDGMENT

We sincerely thank the Education Fund Management Institute of the Republic of Indonesia for its generous financial support, which has facilitated the successful completion of this research.

REFERENCES

[1] S. Resvito, *Mathematics in society and history*. London: Kluwer Academic Publishers, 1992.
[2] U. D’Ambrosio, *An overview of the history of ethnomathematics*. London : Springer, 2016.
[3] R. L. Wilder, *Mathematics as a cultural system*. New York: Pegamon Press, 2014.
[4] U. D’Ambrosio, *Ethnomathematics: Link between traditions and modernity*. Roterdam, The Netherlands: Sense Publishers, 2006.
[5] M. Rosa and M. E. Gavarrete, *An ethnomathematics overview: An introduction*. London : Springer, 2017.
[6] U. D. Ambrosio, “Ethnomathematics and its place in the history and pedagogy of mathematics,” *For Learning Mathematics*, vol. 5, no. 1, pp. 44–48, 2012.
[7] A. Hendriyanto, N. Priatna, D. Juandi, J. A. Dahlan, L. H. Muhaimin, and S. Sahara, “Learning mathematics using an ethnomathematics approach : A systematic literature review,” *Journal of Higher Education Theory and Practice*, vol. 23, no. 7, pp. 59–74, 2023, doi : 10.33423/jhetp.v23i7.6012
[8] D. A. M. Lidinillah, R. Rahman, W. Wahyudin, and S. Aryanto, “Integrating sundanese ethnomathematics into mathematics curriculum and teaching: A

systematic review from 2013 to 2020," *Infin. J.*, vol. 11, no. 1, pp. 33-54, 2022, doi: 10.22460/infinity.v11i1.p33-54.
[9] G. Knijnik, "Differentially positioned language games: ethnomathematics from a philosophical perspective," *Educ. Stud. Math.*, vol. 80, no. 1, pp. 87–100, 2012, doi: 10.1007/s10649-012-9396-8.
[10] Wiryanto, M. G. Primaniarta, and J. R. L. de Mattos, "Javanese ethnomathematics: Exploration of the Tedhak Siten tradition for class learning practices," *J. Math. Educ.*, vol. 13, no. 4, pp. 661-680, 2022, doi: 10.22342/jme.v13i4.pp661-680.
[11] M. Civil, "Culture and mathematics: A community approach," *J. Intercult. Stud.*, vol. 23, no. 2, pp. 133–148, 2002, doi: 10.1080/07256860220151050A.
[12] J. P. Makonye, "Towards a culturally embedded Financial Mathematics PCK framework," *Res. Math. Educ.*, vol. 22, no. 2, pp. 98–116, 2020, doi: 10.1080/14794802.2020.1752788.
[13] R. C. I. Prahmana and U. D'Ambrosio, "Learning geometry and values from patterns: ethnomathematics on the batik patterns of Yogyakarta, Indonesia," *J. Math. Educ.*, vol. 11, no. 3, pp. 439–456, 2020, doi : 10.22342/jme.11.3.12949.439-456.
[14] O. A. Cimen, "Discussing ethnomathematics: Is mathematics culturally dependent?," *Procedia - Soc. Behav. Sci.*, vol. 152, no. 1, pp. 523–528, 2014, doi: 10.1016/j.sbspro.2014.09.215.
[15] D. Muhtadi, Sukirwan, Warsito, and R. C. I. Prahmana, "Sundanese ethnomathematics: Mathematical activities in estimating, measuring, and making patterns," *J. Math. Educ.*, vol. 8, no. 2, pp. 185–198, 2017, doi: 10.22342/jme.8.2.4055.185-198.
[16] R. C. I. Prahmana, "Ethno - realistic mathematics education : The promising learning approach in the city of culture," *SN Soc. Sci.*, vol. 2, no. 12, pp. 1–19, 2022, doi: 10.1007/s43545-022-00571-w.
[17] R. C. I. Prahmana and U. D'Ambrosio, "Learning geometry and values from patterns: Ethnomathematics on the batik patterns of yogyakarta, indonesia," *J. Math. Educ.*, vol. 11, no. 3, pp. 439–456, 2020, doi: 10.22342/jme.11.3.12949.439-456.
[18] G. Ammarell, "Sky calendars of the indo-malay archipelago: Regional diversity/local knowledge," *Cornell University Press*, vol. 45, no. 1, pp. 85–104, 1988, doi: 10.2307/3351177.
[19] M. Saihu, "Creating community based on religion and culture: Social learning in hindu and muslim relationships in Bali," *Edukasi Islami J. Pendidik. Islam*, vol. 10, no. 1, pp. 219–246, 2021, doi: 10.30868/ei.v10i01.861.
[20] A. Jabar, R. Y. Gazali, A. A. Ningrum, M. F. Atsnan, and R. C. I. Prahmana, "Ethnomathematical Exploration on traditional game bahasinan in Gunung Makmur Village the Regency of Tanah Laut," *Math. Teach. Res. J.*, vol. 14, no. 5, pp. 107–127, 2022.
[21] J. Munthahana, M. T. Budiarto, and A. Wintarti, "The application of ethnomathematics in numeracy literacy perspective: A literature review," *Indones. J. Sci. Math. Educ.*, vol. 6, no. 2, pp. 177–191, 2023, doi: 10.24042/ijsme.v6i2.17546.
[22] J. Soebagyo and F. I. Luthfiyyah, "Ethnomathematics exploration of the Great Mosque of Al-Barkah, Bekasi City, through the learning of geometry and transformational geometry," *Indones. J. Sci. Math. Educ.*, vol. 6, no. 2, pp. 152–164, 2023, doi: 10.24042/ijsme.v6i2.17179.
[23] F. Saadah, A. Antariksa, and C. B. Amiuza, "Ethnomathematics: Mathematical concepts in sigale-gale statues," *Indones. J. Sci. Math. Educ.*, vol. 06, no. 2, pp. 1–8, 2016, doi: 10.24042/ijsme.v5i1.15698.

[24] A. Begg, "Ethnomathematics: Why, and what else?," *ZDM Mathematics Education.*, vol. 33, no. 3, pp 71–74, 2001, doi: 10.1007/BF02655697.
[25] J. E. Dodgson, "About research: Qualitative methodologies," *J. Hum. Lact.*, vol. 33, no. 2, pp. 355–358, 2017, doi: 10.1177/0890334417698693.
[26] Lexy J. Moloeng, *Metodologi penelitian kualitatif*. Bandung: PT Remaja Rosdakarya, 2019.
[27] M. B. Miles, A. M. Huberman, and J. Saldaña, *Qualitative Data Analysis*. London: SAGE Publication, 1994.
[28] B. Jaworski, M. G. Bartolini Bussi, S. Prediger, and E. Nowinska, "Cultural contexts for European research and design practices in mathematics education," *Proc. Ninth Congr. Eur. Soc. Res. Math. Educ.*, vol. 10, no. 1, pp. 7–33, 2015.
[29] M. Jurdak, *Learning and teaching real world problem solving in school mathematics*. New York: Springer, 2016.
[30] R. Angraini and F. Rakhmawati, "Ethnomathematics exploration of fish trader activities in the traditional market of Punggulan Village, Asahan Regency," *Indones. J. Sci. Math. Educ.*, vol. 6, no. 2, pp. 213–226, 2023, doi: 10.24042/ijsme.v6i2.17182.
[31] B. Atweh, H. Forgasz, and B. Nebres, *Sociocultural research on mathematics education: An international perspective*. New York: Psychology Press, 2001.
[32] R. Stuart and C. Robert, "Where would formal, academic mathematics stand in a curriculum informed by ethnomathematics? A critical review of ethnomathematics," *Educational Studies in Mathematics.*, vol. 50, no. 1, pp. 79–102, 2002, doi : 10.1023/A:1020532926983.
[33] U. D'Ambrosio, "Literacy, matheracy, and technocracy: A Trivium for Today," *Math. Think. Learn.*, vol. 1, no. 2, pp. 131–153, 1999, doi: 10.1207/s15327833mtl0102_3.
[34] M. Rosa and D. C. Orey, "A trivium curriculum for mathematics based on literacy, matheracy, and technoracy: an ethnomathematics perspective," *ZDM - Int. J. Math. Educ.*, vol. 47, no. 4, pp. 587–598, 2015, doi: 10.1007/s11858-015-0688-1.
[35] P. Gerdes, "Reflections on Ethnomathematics," *Learn. Math.*, vol. 14, no. 2, pp. 19–22, 1994.