INDONESIAN JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION
06 (3) (2023) 416-429
https://ejournal.radenintan.ac.id/index.php/IJSME/index
ISSN: 2615-8639
DOI: 10.24042/ijsme.v5i1.19790
November 2023

MATHEMATICAL FRAMEWORK FOR ACCURATE PRAYER TIMES: INSIGHTS FROM THE *BENCET* TRADITION

Lukman Hakim Muhaimin[1], Yaya S. Kusumah[2*], Dadang Juandi[3], Agus Hendriyanto[4], Sani Sahara[5]

[1,2,3,4,5]Department of Mathematics Education, Faculty of Mathematics and Natural Science Education, Universitas Pendidikan Indonesia, Indonesia

**Corresponding author:* yskusumah@upi.edu

Article Info

Article history:

Received: October 21, 2023
Accepted: November 25, 2023
Published: November 30, 2023

Keywords:

Bencet
Ethnographic
Ethnomathematics
Mathematics education
Prayer times

ABSTRACT

Establishing a crucial connection between religious practices and mathematics is essential for comprehending the regularity and temporal discipline inherent in fulfilling religious duties, notably observed in traditional tools like *bencet* for determining prayer times. This qualitative ethnographic study aims to unveil the mathematical concepts involved in using and crafting *bencet*. This exploration of *bencet* represents the first-ever study in the history of ethnomathematics. Data analysis using the Miles and Huberman model reveals that the community's unconscious use of *bencet tongkat* demonstrates mathematical concepts, particularly in parallel lines, measurements, and the need for flat sides. Meanwhile, crafting *bencet garis* showcases the community's unconscious understanding of mathematical concepts related to parallel lines, perpendicular lines, the use of circles for 90° angles, and measurements. These findings expand our understanding of cultural values and local wisdom, demonstrating their relevance to mathematical concepts. Furthermore, the study provides recommendations for future research, suggesting an exploration of ethnomathematics as an innovative alternative approach to learning.

KERANGKA MATEMATIKA DALAM PENENTUAN WAKTU SOLAT: WAWASAN DARI TRADISI *BENCET*

Kata Kunci:

Bencet
Etnografi
Etnomatematika
Pendidikan matematika
Waktu shalat

ABSTRAK

Menghubungkan praktik ibadah dengan matematika menjadi esensial untuk memahami keteraturan dan disiplin waktu dalam menjalankan kewajiban keagamaan, terutama yang terlihat dalam penggunaan alat tradisional seperti *bencet* untuk menentukan waktu sholat. Studi kualitatif dengan desain etnografi ini bertujuan mengungkap konsep matematika dalam penggunaan dan pembuatan *bencet*. Eksplorasi *bencet* ini merupakan studi pertama dalam sejarah etnomatematika. Analisis data dengan model Miles dan Huberman menunjukkan bahwa penggunaan *bencet tongkat* oleh masyarakat, tanpa kesadaran eksplisit, mengandung konsep matematika, terutama sejajar, pengukuran, dan kebutuhan akan sisi datar. Sementara dalam pembuatan *bencet garis*, masyarakat tanpa disadari menunjukkan pemahaman konsep matematika terkait garis sejajar, garis tegak lurus, penggunaan lingkaran untuk sudut 90°, dan pengukuran. Temuan ini memperluas pemahaman nilai budaya dan kearifan lokal, serta relevansinya dengan konsep matematika. Selain itu, studi ini memberikan rekomendasi bagi penelitian mendatang untuk mengeksplorasi konsep ethnomatematika sebagai pendekatan pembelajaran inovatif.

1. INTRODUCTION

Recognizing that the link between mathematics and culture is not a new concept is essential. History records that since ancient times, civilizations have used mathematical concepts to detail and celebrate their 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 just about mapping the application of mathematics to cultural practices. Instead, it broadens its scope to penetrate cultural aspects involving mathematical concepts [6]–[8]. At its core, it is a deep dive into understanding how culture and mathematics intertwine and impact each other. Research in ethnomathematics is not confined to past cultures but also encompasses emerging or contemporary cultures. Hence, studies on ethnomathematics will remain pertinent over time as cultures continue to evolve alongside human life.

In an ever-growing field of interdisciplinary studies, the convergence of mathematics and cultural practices provides a unique avenue for exploration. This scientific endeavor began a fascinating journey into ethnomathematics, where a complex tapestry of cultural traditions was revealed against a precise mathematical framework. This captivating journey aligns with the research aims, as it seeks 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]. Barton [9] 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 rigour and the cultural intricacies that define human society [10].

Rosa & Orey [8] provide an etymological explanation of ethnomathematics, which comes from three root words in Greek, namely *ethno*, which refers to a natural or sociocultural group; *mathema*, which means explaining and learning, and *thic*, which means method, art, and technique. Therefore, ethnomathematics can be defined as a program related to 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*). This allows them to model the environment in natural and social contexts, aiming to explain and understand a phenomenon (*tics*). Cimen [11] aligns with this theory, which defines ethnomathematics as mathematics practiced among identifiable cultural groups, such as ethno-national communities, working class, children of specific age groups, and professional classes.

Indonesian researchers, such as Muhtadi [12] and Prahmana [13], [14] also contribute to this understanding, asserting that ethnomathematics is 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 and emphasizes the integration of mathematics and culture in various societal contexts.

This research aims to explicitly connect the cultural artifact known as *bencet* with the field of ethnomathematics by exploring its mathematical underpinnings. *Bencet*, also called a sundial, holds traditional significance in determining the commencement of prayer times [15]. The term *bencet* itself 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. As such, determining prayer times becomes a mathematical consideration influenced by the sun's movement.

The usage of *bencet* is explicitly linked to the calculation of the midday and Asr prayer times, as it relies on the sunlight or shadow it produces. This specific application of *bencet* underscores the intersection between mathematical concepts, cultural practices, and religious observances, providing a tangible example of ethnomathematics in action within the context of 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 focal point of inquiry adds a significant layer of cultural specificity to this exploration. Rooted in the cultural tapestry 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 [16]. By meticulously examining *bencet*, the research aims to unveil the mathematical algorithms implicitly embedded in its manufacturing process and the precise determination of prayer times. This tool's interplay of cultural and mathematical elements presents 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 delving into the intricate relationship between cultural specificity and mathematical algorithms in the context of *bencet*, the research seeks to contribute to our understanding of ethnomathematics and the broader discourse on how mathematical concepts are woven into the fabric of diverse cultural practices.

Previous ethnomathematics studies have revealed mathematical concepts from Indonesian cultures [17]–[20]. Literature research reveals that there has been significant growth in the last few decades related to ethnomathematics studies, especially in the context of mathematics teaching in the school environment. This observation shows that most ethnomathematics research is conducted by Indonesian researchers, who consistently contribute to the understanding of mathematics in cultural contexts [7]. However, despite the abundance of research in this domain, no specific study explores aspects of *bencet* or similar phenomena within an ethnomathematics framework [7], [21]. The lack of attention to specific cultural artifacts, such as *bencet*, within the ethnomathematics framework signifies a gap in understanding the intricate intersections between mathematical concepts and culturally specific tools or practices. By addressing this gap, the present research seeks to contribute to the broader field of ethnomathematics and to the refinement of pedagogical approaches that can better incorporate cultural nuances into mathematics education.

The exploration of ethnomathematics within the realm of *bencet* introduces a compelling dimension to the field, given the unique role that *bencet* plays in the daily lives of individuals, particularly within specific cultural contexts. Notably, this research aims to address a significant gap in the existing literature by providing the first dedicated investigation into the ethnomathematics of *bencet*. Despite the undeniable influence of *bencet* on daily activities, it is crucial to emphasize that there has been a conspicuous absence of prior ethnomathematics studies explicitly delving into the intricacies of *bencet*. This notable gap underscores the urgency and importance of conducting a comprehensive exploration that recognizes the presence of *bencet* and scrutinizes 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, thereby enriching the overall discourse on the subject.

As researchers embark on this journey of ethnomathematics, it is essential to acknowledge the broader implications of the investigations undertaken. Beyond the boundaries of academic curiosity, the insights gained from this research have practical significance for communities that use *bencet*. By explaining the mathematical precision behind accurate prayer times, researchers aspire to contribute to academic discourse and the practical improvement of religious practice in a culturally sensitive manner. This research is evidence of the dynamic interconnections that define human society. This reflects a commitment to uncovering layers of complexity in cultural practices and recognizing the symbiotic relationship between tradition and precision.

2. METHOD

This research aims to explore the mathematical concepts contained in *bencet*, focusing on two types of *bencet*: those in the form of artifacts and those that appear in the form of ideas. The research implementation involved three main steps: data analysis before entering the field, data analysis while in the field, and overall data analysis [22]. The research design used was qualitative with an ethnographic approach. This approach allows researchers to understand how mathematical concepts are reflected in that culture [22]–[24]. The data collection techniques in this research align with ethnographic principles, including observation, interviews, documentation, and making field notes with original ethnographic descriptions. Interviews were conducted with two people who deeply understand *bencet*, thus providing rich and nuanced insight into how mathematical concepts are integrated into this culture. Meanwhile, observations were carried out mainly on *bencet* artifacts still in use, especially at the Al Muayyad Mosque in Surakarta. Through this approach, this section not only presents the mathematical concepts contained in the artifacts but also looks at how mathematical ideas are reflected in the everyday culture of the people who use *bencet*.

Data analysis occurred at various stages, encompassing the data collection process and post-collection. The primary method employed was in-depth interviews, with the researcher scrutinizing the participants' responses as the interviews unfolded [22]. When the answers lacked depth for thorough comprehension, the researcher posed additional questions until the data reached a point of credibility and saturation. The researcher adopted the data analysis model proposed by Miles and Huberman [25], involving three key activities: data reduction, data display, and drawing/verifying conclusions. The steps of the analysis are illustrated in Figure 1.

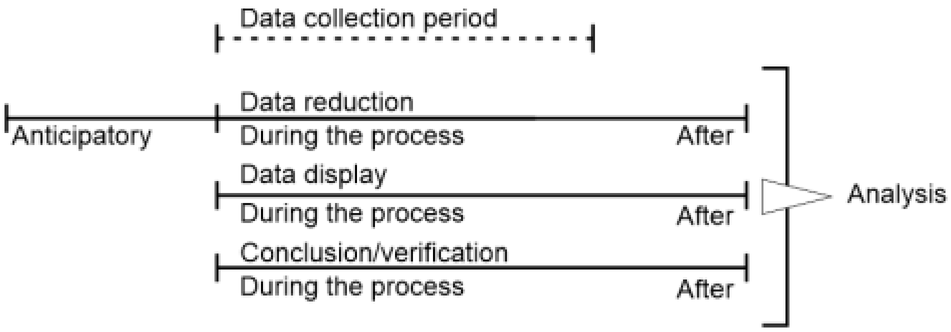


Figure 1. Flow Model in Data Analysis [25]

Examining Figure Y presented earlier, the researcher engaged in proactive data reduction following the data collection phase. This process entails the researcher making decisions, often unconsciously, about selecting a conceptual framework, research questions, research sites, and approaches for data collection. As Miles, M. B., and Huberman [25] outlined, qualitative data analysis is an ongoing and interactive process, persisting until data saturation is attained. The interactive model of data analysis is depicted in Figure 2.

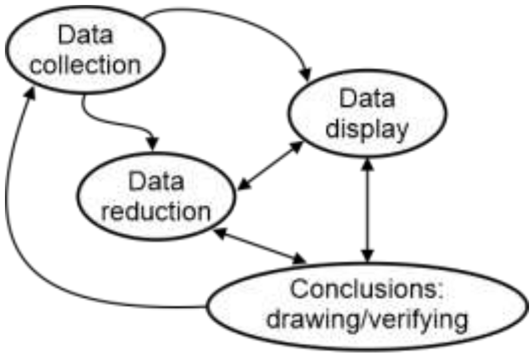
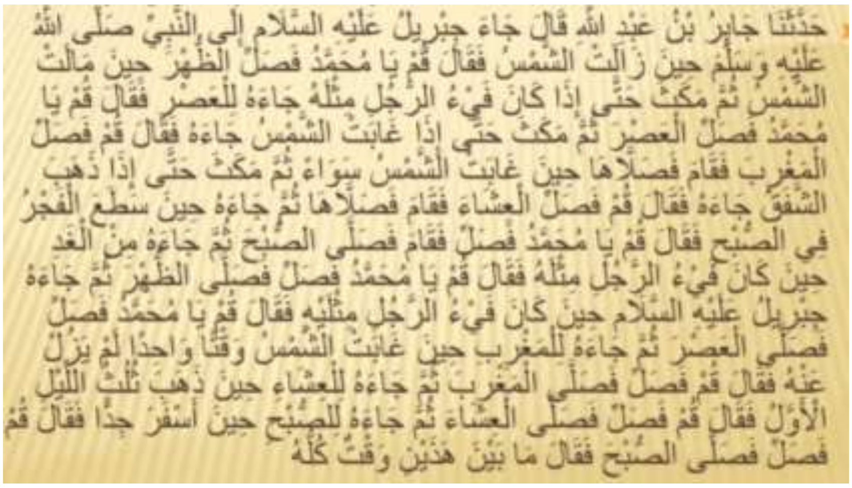


Figure 2. Intercative Model in Data Analyisis Interactive Model in Data Analysis [25]

3. RESULT AND DISCUSSION

3.1 Bencet Tongkat

Researchers categorize this *bencet tongkat* as an idea because this stick-banging concept can be used in various places. This idea of *bencet* emerged based on 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: That Jibril 'Alaihissalam came to the Prophet SAW and said to him: Get up and pray, so the Prophet prayed Dhuhr when the sun had slipped. Then Gabriel came to the Prophet at Asr time and said: get up and pray, so the Prophet performed the Asr prayer when the sun's shadow was equal to the object's length. Then Gabriel came to the Prophet at Maghrib and said, Get up and pray, so the Prophet prayed at Maghrib when the sun had set. Then Jibril came again at the time of Isha' and said: Get up and pray, so the Prophet performed the Isha prayer when the red cloud had disappeared. Then Jibril came at dawn and said: Get up and pray, so the Prophet prayed dawn at the time when the righteous dawn had risen. The next day,* *Gabriel came again for Dhuhr time. Jibril said: Get up and pray, so the Prophet prayed Dhuhr when the shadow of the standing sun had become long. Then Gabriel came again at the time of Ashar when the sun's shadow was twice as long as his body. Then Jibril came again at Maghrib's time when he also came yesterday. Then Gabriel came again at the time of Isha', when half the night had passed, or a third of the night, so the Prophet prayed the Isha' prayer. Then Jibril came again when the dawn of Sadiq had risen and said: Get up and pray the morning prayer. After that, Jibril said: The times between these two times are the time of prayer.*

From the hadith, Javanese people created prayer time markers as *bencet tongkat*. This stick has a specific function to identify two prayer times, namely Dhuhur and Asr. The time for the Dhuhur prayer is indicated by the sun's setting, where an object's shadow shifts or leans towards the East. This shows that this *bencet tongkat*-based prayer time marker utilizes natural phenomena, especially the sun's movement, as a temporal reference. Apart from that, the concept of special time is also found in this context. Special time refers to when an object has no shadow at all. This understanding adds a dimension of complexity to determining prayer times and shows the depth of public knowledge regarding astronomical phenomena.

Figure 4. Illustration of Interview Excerpts

The question is, what is the concept of ethnomathematics contained in it? Before revealing further about ethnomathematics, it is important to pay attention to the following interview excerpt and then look at Figure 4.

Researcher	:	*Earlier, we explained the special time when an object has no shadow. This means that to know the time of Istiwa, the object must be upright on a flat plane. How do you make an object in an upright position?*
Source person	:	*Before the idea of hitting the bencet tongkat, we usually used the body to see the time of the istiwa. When we stand upright, and the shadow is directly below us, then that is a special time. Meanwhile, when we erect the stick, we compare it with our shadow to ensure it also has no shadow.*

The illustration depicted in Figure 4, which is the result of the resource person's explanation, shows that mathematical concepts are being implemented, even though they are unaware of it. The mathematical concept that is developed is about the parallelism of two lines. In mathematics, parallel lines are defined as the position of two lines on a plane that does not have a point of intersection, even if the two lines are extended. Geometrically, parallel lines will never meet because they have the same slope (gradient). The discovery of the stick concept is interesting because the inventors did not realize that by making sticks stand this way, they were implementing mathematical concepts, especially regarding the parallelism of lines. These mathematical concepts can be applied to geometry material in the line parallelism sub-material. Thus, the concept of ethnomathematics, in this case, is fulfilled, where mathematical concepts are embedded in everyday cultural practices without explicit awareness.

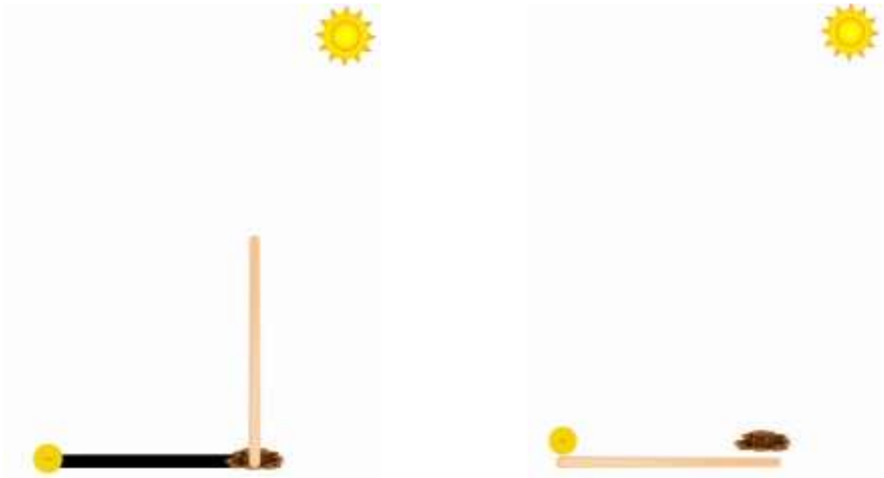
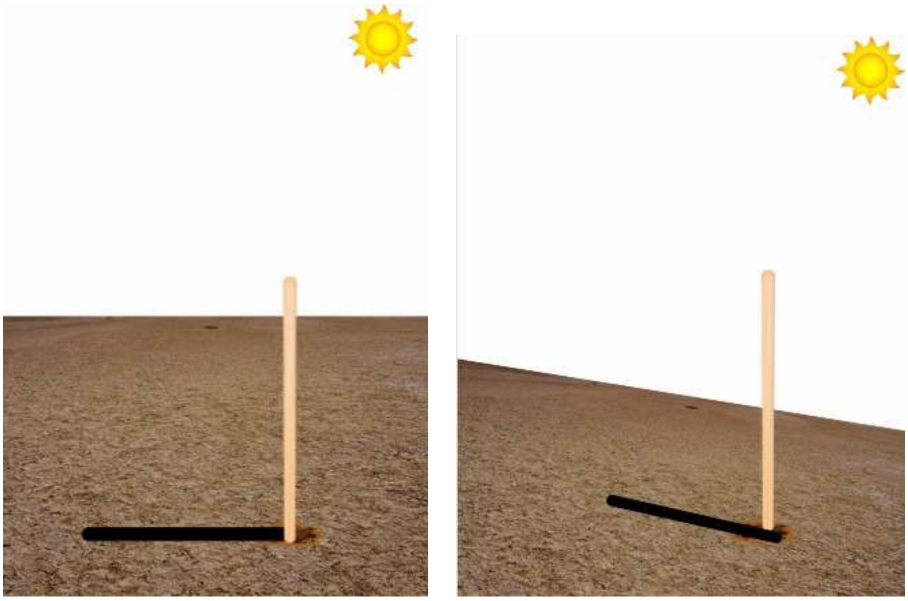


Figure 5. Illustration of the Measurement Process for Determining the Time of Asr Prayers

The approach to measuring Asr prayer times using a *bencet tongkat* illustrates the involvement of mathematical concepts in the daily practices of the community. Two versions of the timing of the Asr prayer, which involve the length of an object's shadow being equal to the length of the object or twice the length of the object, highlight the role of mathematics in determining the moment of worship. This bell type in measuring Asr prayer times does not involve modern measuring instruments such as meters or rulers. This society considers the stick's length as a unit of measurement, both long and short. In determining the time for the Asr prayer, they use a stick made for determining the Istiwa time or make a new stick by placing a dividing line at the top of the shadow. The measurement process is carried out by dropping the stick, where the base of the stick that is not embedded is placed right in the hole where the previous stick was inserted. The tip of the stick is directed to the dividing line created previously. If the length of the shadow is longer or the same length as the stick's length, they conclude that the time for the Asr prayer has arrived. An illustration can be seen in Figure 5. This practice illustrates how people unfamiliar with modern measuring instruments take measurements. Although simple, this approach reflects the mathematical concepts in measuring time, showing creativity and local wisdom in integrating mathematics into everyday life.

Furthermore, people's understanding of the need to make *bencet tongkat* on a flat surface reflects mathematical thinking, which can be identified as ethnomathematics. Two cases of determining the time for the Dhuhur and Asr prayers provide insight into the fact that the context of a flat surface is very relevant in using *bencet tongkat*. First, their awareness of the need for a flat surface in determining the time for the Asr prayer shows an understanding of the accuracy and precision of using a *bencet tongkat*. They realized that if the stick was not placed in a flat plane, this could affect the accuracy of the length of the stick's shadow and, as a result, inaccurate timing of the Asr prayer. In contrast, in the case of special time, the understanding that plane conditions do not affect the position of the shadow as long as the stick is held perpendicular to the sun highlights a simple mathematical concept. The conclusion is that making a bump on a flat surface is necessary, based on observations of this phenomenon, so it can be considered a form of ethnomathematics. Ethnomathematics describes the way a particular culture applies mathematical concepts in their daily lives. In this case, the need for a flat surface as a crucial element in making stick bumps reflects mathematical thinking rooted in that society's cultural practices.



(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 special artifacts that are used for a specific purpose, in this case, to determine the time of Istiwa at the Al Muayyad Mosque in Surakarta. This artifact has its characteristics, with a simple shape, and its existence is limited to certain locations, such as the mosque. The discovery of this type of bell in a mosque indicates that the culture and tradition of using time-measuring devices are still preserved in society, especially in religious contexts. A small hole in the roof of the building, followed by a line below it, is part of this artifact. Determining Istiwa time involves placing the sun's rays at noon in the middle of the line. In other words, these artifacts provide clear visual clues about when the special time is coming. It is important to note that this type of *bencet* has a specific function that only determines the special time. Its limited existence in mosques and its use related to religious practices shows how this traditional tool continues to be used and maintained, inheriting cultural values and local wisdom.

The main advantage lies in its consistency, where this *bencet garis* can be used daily to determine special times. This creates the impression that the line clock functions as a "perpetual clock." Its regularity and accuracy in determining the *istiwa*'s time daily make it a reliable tool for the local community. In the illustration in Figure 7, the round rays moving from east to west approach the line, indicating the sun's movement. When the round ray is in the middle of the line, that is a special time. The movement of this ray is not only limited to traveling west-to-east but also experiences a gradual shift north-south as the moon progresses. This phenomenon creates a cycle that continues to repeat itself. The true north-south line, as seen in Figure 7, provides a visual basis for understanding the movement of sunlight in the context of special time.

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

Regardless of whether the inventor was a mathematician, astronomy expert, or another expert, based on the interviewee's explanation, the interview results indicated that the process of making *bencet garis* indicated the existence of the concept of ethnomathematics in it. The following are the stages of making a *bencet garis* stop that the researcher concluded from the resource person's presentation: (1) Starting by making a circular hole in the roof or roof tiles, (2) Determine the center point on the floor (flat plane) by hanging a weighted rope (thread) from the hole that was made previously, (3) Make a true east-east-west line, namely by observing the movement of sunlight coming out of the hole at two times, namely morning and afternoon, (4) Create a straight line from two points obtained from observations of rays. Making this line also uses rope (thread) by placing the end and base of the rope at each point, (5) If the line obtained does not exactly pass through the center point that has been made, then a line is made parallel to the true east-west line that passes through the center point, (6) After obtaining a true east-west line that passes through the center point, a true north-south line is created by making a line perpendicular to the true east-west line. The way to make it is by making a circle out of paper and folding it into four parts. The resulting circle forms two perpendicular lines that intersect each other at the center point. Then, the circle's center point is placed at the center point of the bend, and one of the lines is adjusted to the true east-west line. Then, you will get a true north-south line. These steps can be illustrated in Figure 8 with A = central point, B = morning ray point, and C = noon ray point.

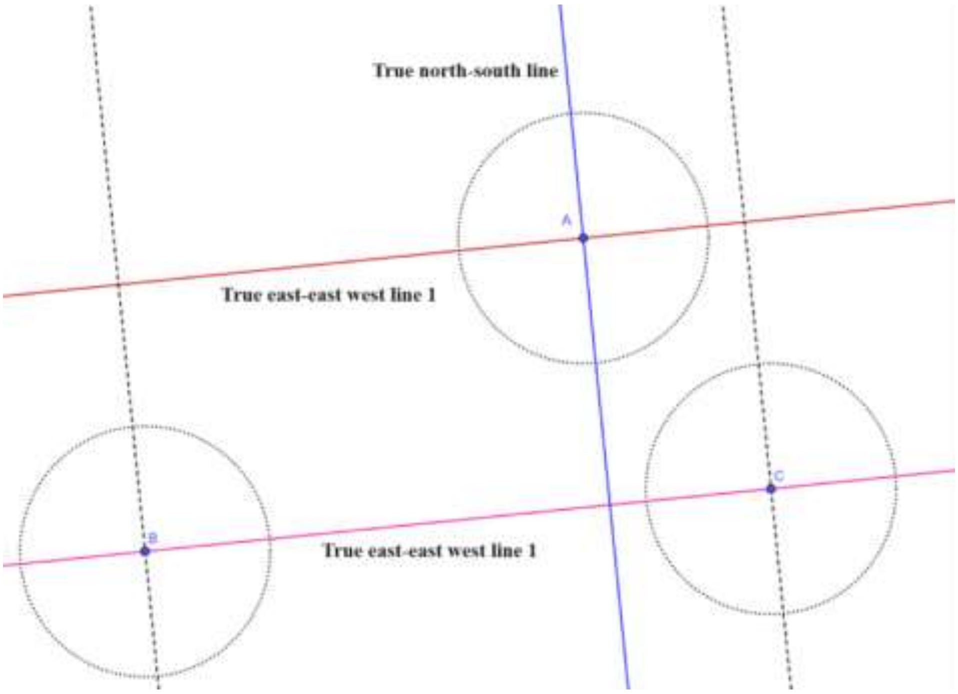


Figure 8. Illustration of the Process of Making *Bencet Garis*

The process of making *bencet garis* involves a lot of mathematical concepts, especially geometric problems. Researchers have adapted the explanation of terms in the stages above into mathematical language, such as parallel lines, perpendicular lines, and center points. However, during the interview, the interviewee only referred to it as a line without distinguishing whether it was a parallel or perpendicular line. Some concepts of ethnomathematics What researchers can reveal in the process of making *bencet* is: (1) Parallel and perpendicular lines: although the source did not explicitly mention these terms, the concept of parallel and perpendicular lines is seen in creating the main lines. Constructing a true east-east-west line and a true north-south line involves understanding the relative relationship between these lines. This concept can be applied in mathematics learning in geometry material in the sub-material of line properties, (2) How to make a perpendicular line: in mathematics, a perpendicular line is defined as two lines that meet to form congruent adjacent angles. This means that the angles formed by making perpendicular lines are right angles (90°). They do not mention the terms right angle or angle measure 90°. However, the method used by making a circle from paper and then dividing it into four parts is a concept that corresponds to the size of the angles of the circle (360°), which is divided into four (90°). This concept can be applied in mathematics learning in geometry and trigonometry, and (3) Measurements in determining parallel lines: looking at Figure 5, it can be seen that when making parallel lines (true east-west line 2), you don't just make arbitrary lines. The designers of *bencet garis* pay attention to a sequence, which refers to the true meaning of parallel lines. Start by making two perpendicular lines that pass through points B and C, as point two describes. Then, create new points on both lines with the same distance so that they pass through the center point. This concept can be applied to measurement material in mathematics learning. Thus, it can be proven that the use of *bencet* as cultural heritage contains a concept of ethnomathematics.

The two forms of *bencet* described previously measure time and reflect the continuity of traditions and cultural values inherent in a particular society. The manufacturing process and the mathematical concepts involved in using *bencet* have been passed down from generation to generation, indicating the existence of cultural values manifested in this mathematical practice [26]. 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*s 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*. Through measuring time and determining the sun's position, mathematical concepts become meaningful in everyday life, proving that ethnomathematics is not just theoretical but relevant in social and cultural reality.

Traditional approaches to teaching mathematics often feel rigid and disconnected from society's social and cultural realities [27]. Mathematics is taught through a formal approach that tends to be normative and dogmatic, causing mathematics learning to feel less meaningful for students. In this context, ethnomathematics emerged as an innovative solution to improve mathematics learning in formal environments. Many studies support the idea that learning mathematics with an ethnomathematics approach can provide more profound meaning for students, allowing them to relate mathematical knowledge to everyday life [7]. Applying ethnomathematics as a pedagogical approach has positive impacts, including increasing student involvement and developing their creativity in understanding and solving mathematical problems. By including cultural and social aspects in mathematics learning, ethnomathematics allows students to better understand mathematics's role in everyday life.

The decision to integrate ethnomathematics in mathematics learning is supported by the idea that mathematics is not a separate entity but is an expression of the development of human culture and thought [28]. Understanding mathematics as an integral part of culture helps students feel involved and contribute to the mathematics learning process. In line with this approach, mathematics education needs to explore and understand the real sociocultural context and reality around students [29]. Contextualizing mathematics learning with students' cultural environments creates more relevant learning and meets students' needs to understand internal values and broader mathematical knowledge [7]. By immersing students in their culture and context, mathematics education can become more inclusive and contribute to solving problems in people's daily lives. In conclusion, ethnomathematics brings greater meaning and relevance to mathematics learning, bridging the division between mathematics and students' cultural contexts.

D'Ambrosio [2], [30] played an important role in developing ethnomathematics by designing the trivium curriculum, a literacy, matheracy, and technocracy approach. This curriculum provides the basis for developing ethnomathematics studies as an approach to mathematics learning. From an ethnomathematics perspective, literacy is a student's ability to process, write, represent, calculate, and use various media. Matheracy is students' ability to interpret and analyze signs and codes to propose models and solutions to everyday problems. Meanwhile, technocracy is defined as students' ability to use and combine various technological instruments in daily activities, with an emphasis on assessing the reasonableness of the results and their contextualization [14], [31], [32].

The meaning of the trivium curriculum does not explicitly highlight cultural elements. This aligns with the view of Gerdes [33], who defines ethnomathematics as "the mathematics implicit in every practice." In other words, ethnomathematics involves applying mathematical concepts in the context of everyday life without excluding culture. This approach recognizes that mathematics is not only normative and formal but also includes cultural dimensions that are inherent in every societal practice. This trivium curriculum approach provides a foundation for bringing mathematical understanding into students' real lives, creating connections between mathematical concepts and their cultural experiences [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 [32]. 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.

This study is limited in its scope as it only uncovers the ethnomathematics aspects without delving into how the findings can be integrated into mathematics education in schools. The focus of the research is primarily on exploring the ethnomathematical dimensions related to bencet, and while it provides valuable insights into cultural practices and mathematical concepts, the direct applicability and integration of these findings into the broader mathematics curriculum have not been thoroughly examined. Future research endeavors may benefit from exploring the practical implications of ethnomathematics studies and investigating how the insights gained can be effectively incorporated into educational settings to enhance the understanding and appreciation of mathematics among students.

4. CONCLUSION

Bencet, *bencet tongkat*, and *bencet garis* have unique functions in determining Istiwa and Asr prayer times. In the discussion, it was found that this practice contains the concept of ethnomathematics, where mathematical concepts are embedded in everyday cultural practices without explicit awareness. The importance of a flat surface is revealed from research findings, where determining the time of the Asr prayer requires a precise flat surface. The public knows the accuracy and precision of using sticks, so a flat surface is crucial in using this traditional tool. This indicates that understanding flat planes is a must in this practice. It was also found that mathematical concepts, such as parallel and perpendicular lines, were unwittingly involved in creating *bencet garis*. The implication is the need for a mathematics learning approach that is contextual and relevant to everyday life so that students can be more involved and understand the meaning of mathematical concepts. This shows that mathematics learning can be more effective when cultural context is integrated.

This research also shows the potential for using ethnomathematics as an innovative approach to teaching mathematics. Integrating ethnomathematics into the mathematics curriculum can make learning more meaningful and relevant for students. Recommendations for future research include further study of ethnomathematics in the context of other cultures and societal traditions, development of mathematics learning materials that integrate ethnomathematics concepts, and analysis of the effectiveness of integrating ethnomathematics in formal education. This research proposes a deeper understanding of the relationship between mathematics and culture, opening the door to improved approaches to mathematics learning that are more contextual and inclusive.

ACKNOWLEDGMENT

Infinite thanks are expressed to the Al Muayyad Surakarta Islamic Boarding School for the hospitality and facilities provided to researchers. Our special appreciation is also expressed to the kyai and ustadz, who have spent time as resource persons in this research. Also, we must thank the Education Fund Management Institute (LPDP) of the Republic of Indonesia for the financial support that has allowed these research activities to run smoothly.

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*. Hamburg : Springer Open, 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*. The Netherlands: Sense Publishers, 2006.

[5] M. Rosa and M. E. Gavarrete, *An Ethnomathematics Overview: An Introduction*. Hamburg : Springer, 2017.

[6] U. D. Ambrosio, "Ethnomathematics and Its Place in the History and Pedagogy of Mathematics," *Learning*, vol. V, 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," vol. XXIII, no. 7, pp. 59–74, 2023.

[8] M. Rosa and D. C. Orey, "Symmetrical Freedom Quilts: The Ethnomathematics of Ways of Communication, Liberation, and Art.," *RLE- Rev. Latinoam. Etnomatemática [electronic only]*, vol. II, no. 2, pp. 52–75, 2009.

[9] B. Barton, "Ethnomathematics: Exploring Cultural Diversity in Mathematics," *Am. Ethnol.*, vol. XXI, no. 4, pp. 922–923, 1996.

[10] J. P. Makonye, "Towards a culturally embedded Financial Mathematics PCK framework," *Res. Math. Educ.*, vol. XXII, no. 2, pp. 98–116, 2020.

[11] O. A. Cimen, "Discussing Ethnomathematics: Is Mathematics Culturally Dependent?," *Procedia - Soc. Behav. Sci.*, vol. CLII, no. 1, pp. 523–528, 2014.

[12] D. Muhtadi, Sukirwan, Warsito, and R. C. I. Prahmana, "Sundanese ethnomathematics: Mathematical activities in estimating, measuring, and making patterns," *J. Math. Educ.*, vol. VIII, no. 2, pp. 185–198, 2017.

[13] R. C. I. Prahmana, "Ethno - Realistic Mathematics Education : The promising learning approach in the city of culture," *SN Soc. Sci.*, vol. II, no. 12, pp. 1–19, 2022.

[14] 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. XI, no. 3, pp. 439–456, 2020.

[15] I. N. F. Nisa', "Penggunaan, Perhitungan, dan Akurasi Jam Bencet dalam Tinjauan Software Accurate Times dan Aplikasi Muslim Pro," *Al-Ahkam J. Ilmu Syari'ah dan Huk.*, vol. VI, no. 1, pp. 89–112, 2021.

[16] M. Saihu, "Creating Community Based on Religion and Culture: Social Learning In Hindu and Muslim Relationships in Bali," *Edukasi Islam. J. Pendidik. Islam*, vol. X, no. 1, pp. 219–246, 2021.

[17] D. S. Padang and M. S. Lubis, "Ethnomathematical Exploration of Traditional Agricultural Tools in Hutamanik Village, Sumbul Regency," *Indones. J. Sci. Math. Educ.*, vol. VI, no. 2, pp. 137–151, 2023.

[18] 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. VI, no. 2, pp. 177–191, 2023.

[19] 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. VI, no. 2, pp. 152–164, 2023.

[20] F. Saadah, A. Antariksa, and C. B. Amiuza, "Ethnomathematics: Mathematical

Concepts in Sigale-Gale Statues," *Indones. J. Sci. Math. Educ.*, vol. VI, no. 2, pp. 1–8, 2016.
[21] R. Rusli and T. N. Safaah, "Research Trend on Ethnomathematics from 2012 To 2022: A Bibliometric Analysis," *Indones. J. Sci. Math. Educ.*, vol. VI, no. 1, pp. 37–47, 2023.
[22] Lexy J. Moloeng, *Metodologi Penelitian Kualitatif*. Bandung: PT Remaja Rosdakarya, 2019.
[23] J. Creswell, *Educational Research*. California : SAGE, 2015.
[24] S. Sutama, *Metode Penelitian Pendidikan Kuantitatif, Kualitatif, PTK, Mix Method, R&D*. sukoharjo: CV Jasmine, 2019.
[25] M. B. Miles, A. M. Huberman, and J. Saldaña, *Qualitative Data Analysis*. London: SAGE Publication, 1994.
[26] 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. X, no. 1, pp. 7–33, 2015.
[27] M. Jurdak, *Learning and Teaching Real World Problem Solving in School Mathematics*. New York: Springer, 2016.
[28] 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. VI, no. 2, pp. 213–226, 2023.
[29] B. Atweh, H. Forgasz, and B. Nebres, *Sociocultural research on mathematics education: An international perspective*. New York: Psychology Press, 2001.
[30] U. (1993). D'Ambrosio, "Etnomatemática: Um programa [Ethomathematics: A program]. A Educação Matemática em Revista," vol. I, no. 1, pp. 5–11, 1993.
[31] U. D'Ambrosio, "Literacy, Matheracy, and Technocracy: A Trivium for Today," *Math. Think. Learn.*, vol. I, no. 2, pp. 131–153, 1999.
[32] 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. XLVII, no. 4, pp. 587–598, 2015.
[33] P. Gerdes, "Reflections on Ethnomathematics," *Learn. Math.*, vol. XIV, no. 2, pp. 19–22, 1994.