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Ethnomodelling of Menggelek Tobu: Bridging Indigenous Mechanisms and Mathematical Formalism of Cylindrical Rotation

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A B S T R A C T
This study explores mathematical concepts embedded in the traditional Malay activity known as menggelek tobu (rolling sugarcane). The research aims to identify mathematical structures inherent in this cultural practice and transform them into meaningful learning resources for mathematics education. A qualitative ethnographic approach was employed through field observation, documentation, and ethnomathematical analysis. The results reveal that the rolling sugarcane activity involves implicit mathematical concepts, including cylindrical geometry, rotational motion, and optimization of mechanical force. The sugarcane trunk can be modeled mathematically as a cylinder undergoing rolling motion, where the linear displacement is related to angular displacement through the relation $s=r\theta$. In addition, the optimization of rolling force can be represented through frictional mechanics $F=\mu mg$. These findings indicate that local cultural practices contain embedded mathematical reasoning that can be contextualized for teaching mathematics. Integrating ethnomathematics into mathematics education may improve conceptual understanding while strengthening cultural relevance in learning

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INTRODUCTION

Ethnomathematics has emerged as a transformative approach in mathematics education that challenges the traditional perception of mathematics as a purely abstract and universal discipline. Instead, it emphasizes that mathematical knowledge is deeply embedded in the cultural practices, social interactions, and daily activities of human life. D'Ambrosio (1985) introduced this concept by asserting that mathematics is fundamentally a cultural product shaped by diverse social contexts. This perspective redefines mathematics as a dynamic and evolving construct that reflects the lived experiences of different communities. Consequently, mathematical ideas are not only produced in formal institutions such as schools and universities but also emerge organically within traditional practices, local wisdom, and community-based knowledge systems.

From this standpoint, mathematics can be understood as a form of social construction that develops through human interaction with the environment. Cultural activities such as agriculture, architecture, trading, and craftsmanship inherently involve mathematical reasoning, even when not explicitly recognized as such. Bishop (2004) further strengthened this perspective by identifying six universal mathematical activities present across all cultures: counting, locating, measuring, designing, playing, and explaining. These activities demonstrate that mathematical thinking is a fundamental aspect of human cognition and is deeply intertwined with cultural practices. Therefore, ethnomathematics provides a framework for uncovering and analyzing the implicit mathematical structures embedded in everyday life.

The development of ethnomathematics has also led to the emergence of ethnomodelling, which seeks to connect informal cultural knowledge with formal mathematical representations. Rosa & Orey (2011) describe ethnomodelling as a process through which cultural practices can be translated into mathematical models, thereby bridging the gap between local knowledge and academic mathematics. This approach allows researchers and educators to reinterpret traditional activities using formal mathematical language, making them accessible for instructional purposes. Through ethnomodelling, cultural phenomena are no longer viewed merely as heritage practices but also as sources of mathematical insight and innovation.

Recent studies have demonstrated that integrating ethnomathematics into the learning process has significant educational benefits. Culture-based learning approaches have been shown to improve students' conceptual understanding by connecting abstract mathematical ideas with real-life experiences. Research by Rosa & Orey (2021) indicates that students who engage with culturally relevant mathematical contexts are more likely to develop meaningful understanding and retain knowledge effectively. Similarly, Chavarria & Albanese (2023) found that contextual learning rooted in cultural practices enhances students' ability to interpret and apply mathematical concepts. These findings highlight the importance of incorporating ethnomathematical perspectives into modern educational frameworks.

In the Indonesian context, ethnomathematics research has been widely conducted across various cultural domains, including traditional weaving, vernacular architecture, and decorative patterns. These studies have successfully identified mathematical concepts such as symmetry, geometric transformations, and proportional reasoning within cultural artifacts. However, most existing research tends to focus on static objects, limiting the exploration of mathematics to geometric analysis. As noted by Weldeana & Leung (2025), ethnomathematical investigations often remain confined to visual and structural patterns without extending into dynamic processes that involve motion, force, and energy. This limitation suggests the need for broader analytical approaches that incorporate physical and mechanical aspects of cultural practices.

One cultural practice that offers significant potential for such exploration is the Menggelek Tobu tradition found in the Kuok Malay community. This activity involves rolling sugarcane trunks as a method of transportation after harvesting. Previous studies on this tradition have identified basic mathematical concepts such as two-dimensional and three-dimensional geometry, as well as geometric transformations and angular relationships. While these findings provide valuable initial insights, they remain largely descriptive and do not fully capture the dynamic nature of the activity. In particular, aspects related to motion, mechanical interaction, and energy efficiency have not been thoroughly examined from a mathematical modelling perspective. From the viewpoint of classical mechanics, the rolling motion observed in the Menggelek Tobu activity can be analyzed using fundamental mathematical relationships. The movement of a cylindrical object rolling without slipping can be described by the relationship between linear displacement and angular displacement, expressed as $s=r\theta$, while the force required to initiate motion is influenced by friction, represented as $F=\mu mg$. These principles indicate that the activity involves not only geometric reasoning but also kinematic and mechanical concepts. The efficiency of rolling compared to dragging or lifting demonstrates an implicit understanding of energy optimization, suggesting that traditional practices embody sophisticated forms of practical knowledge.

Based on this description, a research gap can be identified: the limited number of ethnomathematician studies that develop mathematical models of dynamic cultural activities. Therefore, this study aims to integrate the analysis of geometry, rotational motion, and mechanics in the Menggelek Tobu activity. The novelty of this research lies in the development of an ethnomathematics approach that is not only descriptive but also analytical through the formulation of a mathematical model based on dynamic phenomena. Thus, this research contributes to the development of more comprehensive ethnomathematical modeling and supports contextual and culturally based mathematics learning.

Therefore, this study aims to:

1. Identify mathematical concepts embedded in the rolling sugarcane activity
2. Develop a mathematical model representing the motion of the sugarcane trunk
3. Explore the educational potential of this activity as a contextual learning resource in mathematics education.

LITERATURE REVIEW

Ethnomathematics

Ethnomathematics is a field of study that reconceptualizes mathematics as a discipline deeply embedded within cultural, social, and historical contexts rather than as a purely abstract and universal body of knowledge. The term was introduced by D'Ambrosio (1985), who argued that mathematics develops through human activity and reflects the values, practices, and needs of specific cultural groups. From this perspective, mathematics is not neutral or culture-free, but rather a product of human civilization that evolves over time. This view aligns with constructivist theories of knowledge, which assert that understanding is actively constructed through experience. Consequently, ethnomathematics positions mathematical knowledge as something that is lived, practiced, and continuously shaped by social interaction.

A central idea in ethnomathematics is that every cultural group develops its own mathematical systems based on its environmental conditions and practical needs. These systems may take the form of traditional measurement units, agricultural techniques, architectural designs, navigation methods, or artistic patterns. For example, indigenous counting systems, symmetrical motifs in weaving, and spatial organization in traditional houses all demonstrate the presence of mathematical reasoning. Bishop (2004) reinforced this idea by identifying six universal mathematical activities counting, locating, measuring, designing, playing, and explaining that exist across all cultures. This framework highlights that mathematical thinking is a fundamental human activity, even when it is not formally expressed using symbolic notation. Thus, ethnomathematics provides a lens for uncovering implicit mathematical structures embedded in everyday life.

The development of ethnomathematics has been further enriched by the concept of ethnomodelling, which bridges the gap between informal cultural knowledge and formal mathematical representation. Rosa & Orey (2011) emphasized that ethnomodelling allows cultural practices to be translated into mathematical models, enabling a deeper understanding of both domains. Through this process, traditional activities can be analyzed using formal mathematical tools such as equations, graphs, and geometric representations. Ethnomodelling not only validates local knowledge systems but also integrates them into academic discourse, making mathematics education more inclusive and meaningful. This approach demonstrates that local wisdom and scientific knowledge are not separate entities but can coexist and complement each other.

In addition to its theoretical significance, ethnomathematics has important implications for education, particularly in enhancing students' engagement and conceptual understanding. Studies have shown that when mathematical concepts are presented in culturally relevant contexts, students are more likely to develop meaningful learning experiences. Rosa & Orey (2021) found that integrating ethnomathematics into classroom instruction strengthens the connection between abstract concepts and real-life applications, thereby improving comprehension and retention. Similarly, Chavarria & Albanese (2023) demonstrated that culture-based learning environments encourage active participation and critical thinking. By recognizing students' cultural backgrounds as valuable resources, educators can create more inclusive and responsive learning environments that support diverse learners.

Furthermore, ethnomathematics plays a crucial role in preserving and revitalizing cultural heritage in the face of globalization and modernization. By incorporating cultural practices into formal education, younger generations are encouraged to appreciate and sustain their traditional knowledge systems. This aligns with the perspective of Weldeana & Leung (2025) who argued that studying the mathematical aspects of cultural artifacts contributes to both cultural preservation and academic enrichment. Ethnomathematics therefore creates a synergy between maintaining cultural identity and advancing scientific knowledge. Overall, this field underscores that mathematics is not merely a set of abstract rules, but a dynamic, culturally situated discipline that evolves alongside human society and offers powerful opportunities for contextual and meaningful education.

Mathematical Modelling

Mathematical modelling is a fundamental process that enables the translation of real-world phenomena into formal mathematical representations through symbols, equations, and logical structures. It serves as a bridge between reality and abstraction, allowing complex situations to be understood, analyzed, and predicted using mathematical tools. According to Leiss and Blum (2007), modelling involves a cyclic process that includes understanding a real situation, simplifying it, mathematizing it, and interpreting the results back in the real context. This process highlights that mathematical modelling is not merely about computation but also about reasoning, interpretation, and validation. In the context of ethnomathematics, modelling becomes particularly important as it provides a structured way to reinterpret cultural practices through formal mathematical lenses.

Within ethnomathematics, mathematical modelling functions as a conceptual bridge that connects local cultural knowledge with academic mathematical concepts. (Rosa & Orey, 2024) emphasized that ethnomodelling allows cultural activities to be translated into mathematical representations, thereby legitimizing local knowledge systems within formal education. Through this approach, traditional practices such as agricultural techniques, craftsmanship, and transportation methods can be analyzed using mathematical frameworks. This not only enriches mathematical understanding but also affirms that cultural practices contain valuable intellectual contributions that are often overlooked in conventional curricula.

A key aspect of mathematical modelling is the simplification of complex real-world phenomena into idealized forms that can be more easily analyzed. In the case of the rolling sugarcane activity, the irregular shape of a sugarcane trunk can be approximated as a perfect cylinder. This assumption allows the application of geometric and physical principles without significantly altering the essence of the phenomenon. According to Box (1976), "all models are wrong, but some are useful," emphasizing that simplification is an inherent and necessary part of modelling. By reducing complexity, researchers can focus on key variables such as radius, mass, and surface interaction, making the phenomenon more tractable for analysis while still preserving its cultural meaning.

Mathematical modelling also facilitates the exploration of abstract relationships that govern physical phenomena. One fundamental relationship in rolling motion is the connection between linear displacement and angular displacement:

$$s=r\theta$$

This equation shows that the distance traveled by a rolling object is proportional to its radius and the angle through which it rotates. Such relationships provide insight into how rotational motion translates into linear movement, forming a core concept in both geometry and kinematics. Through this formulation, students can move from observing a physical activity to understanding the underlying mathematical structure, thereby bridging experiential knowledge with theoretical understanding. In addition to geometric relationships, mathematical modelling enables the integration of mechanical principles such as force and friction. The motion of a rolling sugarcane trunk is influenced by the frictional force between the trunk and the ground surface, which can be expressed as:

$$F=\mu mg$$

This equation explains that the force required to initiate or sustain motion depends on the coefficient of friction, the mass of the object, and gravitational acceleration. By incorporating such principles, modelling extends beyond pure mathematics into applied physics, allowing for a more comprehensive analysis of real-world phenomena. This interdisciplinary approach reflects the interconnected nature of knowledge and highlights the practical relevance of mathematics in everyday life.

Furthermore, mathematical modelling provides a framework for analyzing efficiency and optimization in human activities. The rolling method used in transporting sugarcane is significantly more energy-efficient than dragging or lifting because it minimizes frictional resistance and distributes energy between translational and rotational motion. According to Newton (1979), motion is governed by fundamental laws that relate force, mass, and acceleration, forming the basis for understanding such efficiency. By applying these principles, modelling reveals that traditional practices often embody optimized solutions developed through experience and experimentation. This demonstrates that local knowledge systems are not merely intuitive but are grounded in practical reasoning that aligns with scientific principles.

Finally, mathematical modelling within the ethnomathematical framework holds significant pedagogical value. It transforms cultural activities into meaningful learning contexts that make abstract mathematical concepts more accessible and engaging. Students are able to see the direct application of mathematics in their daily lives, which enhances motivation and deepens conceptual understanding. As noted by Schoenfeld (2016), effective mathematical learning occurs when students actively engage in problem-solving and sense-making processes. By integrating modelling with cultural contexts, educators can create learning experiences that are not only intellectually rigorous but also culturally relevant and inclusive. Thus, mathematical modelling serves not only as an analytical tool but also as a powerful strategy for enriching mathematics education.

Ethnomathematics in Education

Integrating ethnomathematics into mathematics education represents a paradigm shift that redefines mathematics as a culturally situated and contextually meaningful discipline. Rather than viewing mathematics as a set of abstract rules detached from everyday life, this approach positions it as a living body of knowledge that emerges from human activities and social practices. D'Ambrosio (1985) emphasized that mathematics education should acknowledge cultural diversity and incorporate learners lived experiences. This perspective aligns with contemporary educational theories that advocate for contextual and student-centered learning, where knowledge is constructed through meaningful engagement with real-world situations.

One of the primary advantages of ethnomathematics in education is its ability to create contextual learning environments. Contextual learning occurs when mathematical concepts are connected to students' daily experiences, making abstract ideas more concrete and understandable. For instance, concepts such as symmetry can be explored through batik patterns, measurement through agricultural practices, and arithmetic through traditional market transactions. According to Lave (1991), learning is most effective when it is embedded within authentic contexts and social practices. By situating mathematics within familiar cultural activities, students can better grasp its relevance and application in real life.

Furthermore, ethnomathematics enhances students motivation and engagement in learning. When learners recognize that mathematics is part of their own cultural environment, they are more likely to develop positive attitudes toward the subject. Research by Rosa and Orey (2011) indicates that culturally relevant pedagogy increases student participation and fosters a deeper connection with mathematical content. This is particularly important in addressing the perception that mathematics is difficult or irrelevant. By presenting mathematics through familiar cultural contexts, educators can create a more engaging and inclusive learning atmosphere.The integration of ethnomathematics also promotes inclusivity and cultural responsiveness in education. When students see their cultural backgrounds reflected in the curriculum, they develop a sense of recognition and belonging. This contributes to the formation of positive academic identities and enhances self-confidence in learning mathematics. Ladson Billings (1995) argued that culturally relevant teaching empowers students intellectually, socially, and emotionally by using cultural referents to impart knowledge. In this way, ethnomathematics not only supports academic achievement but also fosters cultural pride and respect for diversity.

Another significant impact of ethnomathematics is the improvement of conceptual understanding. Traditional mathematics instruction often emphasizes procedural knowledge, leading students to memorize formulas without fully understanding their meaning. In contrast, ethnomathematical approaches encourage students to explore the underlying concepts through real-world applications. For example, geometric principles can be understood through traditional architecture, while proportional reasoning can be observed in craft-making processes. According to (Skemp, 1976), relational understanding, knowing both what to do and why is more meaningful and durable than instrumental understanding. Ethnomathematics facilitates this relational understanding by linking theory with practice.

In addition, ethnomathematics fosters higher-order thinking skills such as critical thinking, problem-solving, and reasoning. When students analyze cultural practices mathematically, they engage in processes of interpretation, abstraction, and generalization. These processes are essential for developing mathematical literacy and analytical competence. Bishop (2004) emphasized that effective mathematics learning involves active problem-solving and sense-making rather than passive reception of information. By encouraging students to investigate and model real-life situations, ethnomathematics supports the development of these essential cognitive skills. Moreover, ethnomathematics encourages interdisciplinary learning by integrating mathematics with other fields such as culture, history, and science. Cultural practices often involve complex interactions between physical processes and social meanings, providing opportunities to connect mathematics with physics, engineering, and social studies. For instance, analyzing the rolling motion of objects in agricultural activities involves both mathematical modelling and mechanical principles. This interdisciplinary approach not only enriches students' understanding but also reflects the interconnected nature of knowledge in real-world contexts.

Overall, ethnomathematics significantly enriches mathematics education by providing contextual relevance, cultural inclusivity, and deeper conceptual understanding. It transforms mathematics from a purely formal discipline into a meaningful tool for interpreting and engaging with the world. By connecting students with their cultural heritage while developing their mathematical competencies, ethnomathematics contributes to a more holistic and human-centered educational experience. As such, it offers a powerful framework for designing learning environments that are not only academically rigorous but also socially and culturally responsive.

METHODOLOGY

This study employed a qualitative ethnographic approach to explore the mathematical concepts embedded in the cultural practice of Menggelek Tobu (rolling sugarcane). This approach is appropriate because it allows the researcher to understand phenomena within their natural cultural setting, focusing on meaning, context, and human activity. As emphasized by Clifford (1973) ethnography aims to produce a deep and contextualized understanding of cultural practices through detailed observation and interpretation. In this study, the rolling sugarcane activity is not only examined as a physical process but also interpreted as a cultural practice that contains implicit mathematical reasoning. The qualitative nature of the research allows for an in-depth exploration of how local knowledge is constructed, practiced, and understood within the community.

Data Collection

Data were collected through three main techniques, namely field observation, photographic documentation, and ethnomathematical interpretation. Each method plays a complementary role in ensuring that the data obtained are rich, contextual, and analytically meaningful.

1. Field Observation

Field observation was conducted to directly examine the Menggelek Tobu activity in its natural setting. Through this method, the researcher observed how farmers roll sugarcane trunks, the techniques used, the direction of motion, and the interaction between the sugarcane and the ground surface. Attention was also given to the physical characteristics of the sugarcane, such as its cylindrical shape, length, and surface texture. This method allows the researcher to capture authentic practices without manipulation, ensuring that the data reflect real-life conditions. According to Alghar & Fauzan (2025), observation is a fundamental tool in ethnographic research because it enables the identification of patterns of behavior and cultural meaning embedded in everyday activities.

2. Photographic Documentation

Photographic documentation was used to support and strengthen the observational data. Images were taken to capture key moments of the rolling process, the positioning of the sugarcane, and the movement patterns during rolling. These visual records serve as permanent data that can be repeatedly analyzed, allowing for more detailed examination of geometric shapes and motion characteristics. Photographs also help in identifying aspects that may not be fully noticed during direct observation. As explained by Batiibwe (2025) visual documentation enhances ethnographic research by providing rich descriptive evidence that complements written field notes and supports deeper analysis.

3. Ethnomathematical Interpretation

Ethnomathematical interpretation was carried out to connect the observed cultural practices with formal mathematical concepts. In this stage, the researcher analyzed the rolling activity by identifying its mathematical elements, such as the cylindrical form of the sugarcane, rotational motion, and the forces involved in movement. This interpretation requires both cultural understanding and mathematical reasoning to ensure that the analysis remains accurate and meaningful. The process follows the ethnomodelling approach proposed by Rosa & Orey (2011) which emphasizes translating cultural practices into mathematical representations without losing their original context.

Data Analysis

Data analysis in this study involved three stages: identification of cultural activity, extraction of mathematical concepts, and mathematical modelling. These stages were conducted systematically to transform qualitative observations into structured mathematical understanding.

1. Identification of Cultural Activity

The first stage involved identifying and describing the Menggelek Tobu activity in detail. The researcher analyzed how the activity is performed, including the process of placing the sugarcane on the ground, initiating the rolling motion, and maintaining movement. This stage also included identifying the physical characteristics of the sugarcane, such as its cylindrical shape and uniform structure, as well as the environmental conditions influencing the activity. The goal of this stage is to obtain a comprehensive understanding of the cultural practice as a whole. This step is essential because it provides the foundation for further analysis and ensures that the interpretation remains grounded in real-world observations.

2. Extraction of Mathematical Concepts

The second stage involved extracting mathematical concepts embedded within the identified activity. The researcher translated observed phenomena into mathematical ideas, such as recognizing the sugarcane trunk as a cylinder in geometry, identifying rolling motion as rotational movement, and relating displacement to angular rotation. Concepts such as linear distance, radius, angle of rotation, and frictional force were identified from the activity. This process reflects the idea proposed by Bishop (2004) that mathematical thinking is present in cultural practices through activities like measuring, designing, and explaining. This stage bridges the gap between informal knowledge and formal mathematical concepts.

3. Mathematical Modelling

The final stage involved constructing mathematical models to represent the extracted concepts. In this stage, the researcher formulated equations and relationships that describe the rolling motion of the sugarcane. For example, the relationship between linear displacement and angular rotation, as well as the influence of friction on movement, were expressed mathematically. Simplifying assumptions were made, such as modeling the sugarcane as an ideal cylinder, to facilitate analysis. This stage transforms qualitative insights into quantitative representations, enabling a deeper and more systematic understanding of the phenomenon. Mathematical modelling also provides a basis for applying these concepts in educational contexts, making cultural practices relevant as learning resources.

Overall, this methodological framework integrates ethnographic observation with mathematical analysis to produce a comprehensive understanding of cultural practices. By combining data collection and systematic analysis, this study demonstrates how local cultural knowledge can be explored, interpreted, and transformed into formal mathematical concepts without losing its original meaning and context.

RESULT AND DISCUSSION

Cultural Description of the Rolling Sugarcane Activity

Field observations reveal that the traditional activity known as menggelek tobu (rolling sugarcane) is widely practiced in rural agricultural communities as an efficient technique for transporting harvested sugarcane trunks. This practice is particularly common in areas where manual labor dominates agricultural processes and access to mechanical transportation is limited. Instead of lifting or dragging the heavy trunks, farmers roll them along the ground surface, utilizing the natural cylindrical shape of the sugarcane. This method significantly reduces physical effort and allows farmers to move large quantities of sugarcane more efficiently. From an anthropological perspective, such practices reflect the adaptive strategies developed by communities to optimize labor within environmental and technological constraints.

The activity typically begins after the sugarcane has been harvested and cut into manageable trunk segments. These segments generally range from 2 to 3 meters in length and have a relatively uniform cylindrical structure, making them suitable for rolling motion. Farmers carefully position each trunk horizontally on the ground, ensuring stability before initiating movement. The preparation stage is crucial because the alignment of the trunk influences the ease of rolling and the direction of movement. This initial setup demonstrates an implicit understanding of balance and object positioning, which are fundamental concepts in both geometry and mechanics.

To initiate motion, farmers apply a forward force using their hands or feet, depending on the size and weight of the trunk. The force is applied tangentially to the surface of the sugarcane, causing it to rotate about its central axis. As the trunk begins to roll, it exhibits a combination of rotational and translational motion. This coordinated movement allows the sugarcane to advance forward while continuously rotating. Such motion corresponds to what is known in physics as rolling without slipping, where the point of contact between the object and the ground momentarily remains stationary. This phenomenon reflects a practical understanding of motion that aligns with principles described in classical mechanics.

During the rolling process, the trunk moves smoothly across the ground surface with relatively low resistance. The rolling motion minimizes frictional forces compared to dragging, where the entire surface of the object is in contact with the ground. Instead, only a small portion of the trunk touches the ground at any given moment, reducing energy loss. This efficiency illustrates an intuitive grasp of mechanical principles, particularly the relationship between friction and motion. According to Newton (1979), the behavior of moving objects is governed by laws that relate force, motion, and resistance, all of which can be observed implicitly in this activity.

The effectiveness of the rolling method demonstrates the presence of practical mechanical knowledge that has been developed and refined through generations of agricultural experience. Farmers may not formally articulate the scientific principles behind their actions, but their techniques reveal a deep understanding of efficiency and optimization. This aligns with the ethnomathematical perspective that knowledge is often embedded in practice rather than expressed in formal language. D'Ambrosio (1985) emphasized that mathematical thinking naturally arises from cultural activities, suggesting that everyday practices can serve as sources of mathematical insight.

From a cultural standpoint, the Menggelek Tabu activity also reflects communal knowledge and shared practices within the community. The technique is typically learned through observation and participation rather than formal instruction, indicating a process of informal knowledge transmission. This form of learning highlights the role of social interaction in the development of practical skills. As noted by Lave (1991) knowledge is constructed within social contexts and is closely tied to participation in cultural practices. Thus, the rolling sugarcane activity not only represents a physical task but also a form of situated learning.

Although farmers may not explicitly describe their actions using mathematical terminology, their practices reflect an intuitive understanding of geometric and mechanical concepts. The cylindrical shape of the sugarcane, the rotational motion during rolling, and the efficient use of force all indicate the presence of underlying mathematical reasoning. These implicit concepts demonstrate that mathematics exists beyond formal education and is deeply embedded in daily life. Bishop (2004) argued that mathematical thinking is present in all cultural activities, even when it is not formally recognized.

From an ethnomathematical perspective, the rolling sugarcane activity provides a valuable opportunity to analyze how mathematical ideas are embedded within traditional knowledge systems. By examining both the geometric structure of the sugarcane and the mechanics of its movement, researchers can formalize and interpret these practices using modern mathematical frameworks. This process not only reveals the richness of local knowledge but also demonstrates its relevance to academic disciplines. Furthermore, it supports the integration of cultural practices into mathematics education, making learning more contextual, meaningful, and connected to students lived experiences.

Identification of Mathematical Concepts

The analysis of the rolling sugarcane activity reveals a rich set of mathematical concepts embedded within the practice, demonstrating that everyday cultural activities can serve as meaningful sources of mathematical knowledge. These concepts include geometric representation, rotational motion, measurement relationships, and optimization of mechanical force. From an ethnomathematical perspective, such findings support the idea that mathematical thinking is not confined to formal education but emerges naturally from human interaction with the environment. As emphasized by D'Ambrosio (1985) mathematical ideas develop through cultural practices and reflect the lived experiences of communities.

One of the most prominent mathematical concepts observed in this activity is the geometric structure of the sugarcane trunk. Visually, the trunk closely resembles a cylindrical object, characterized by a circular cross-section and a relatively consistent radius along its length. This natural form is crucial because it enables smooth rolling motion when the trunk is placed on the ground. The uniformity of its shape reduces irregularities in movement, allowing for more stable and predictable motion. This observation highlights how geometric properties directly influence physical behavior in real-world contexts.

From a mathematical standpoint, a cylinder is defined as a three-dimensional geometric solid composed of two congruent and parallel circular bases connected by a curved lateral surface. The fundamental parameters that describe a cylinder include its radius, diameter, height (or length), and surface area. According to classical geometry principles discussed by Euclid, such shapes can be analyzed through spatial relationships and measurement properties. In the context of sugarcane, the cylindrical approximation simplifies the analysis while maintaining the essential characteristics of the object. The volume of a cylindrical object is one of the key measurable properties that can be derived mathematically. It represents the amount of space occupied by the object and is calculated using the following formula:

$$V=\pi r^2 L$$

In this equation, r represents the radius of the circular base, and L represents the length of the cylinder. This formula illustrates how geometric abstraction allows natural objects, such as sugarcane trunks, to be quantified and analyzed systematically. The ability to model the sugarcane trunk as a cylinder demonstrates the process of mathematical abstraction, where complex real-world objects are simplified into ideal forms for analysis. Although the actual shape of sugarcane may not be perfectly uniform, this approximation allows researchers to apply mathematical principles effectively. As noted by Box (1976), models are simplifications of reality that are useful for understanding key relationships. In this case, the cylindrical model provides a foundation for analyzing both geometric and mechanical aspects of the activity.

Another important mathematical concept identified in this activity is rotational motion. When farmers apply force to the sugarcane trunk, it begins to rotate around its central axis while simultaneously moving forward. This type of motion combines rotation and translation, forming what is known in physics as rolling motion. The rotational aspect is characterized by the turning of the object, while the translational aspect refers to the forward displacement of its center of mass. This dual motion highlights the interconnectedness of geometric and physical concepts.

The relationship between rotational motion and linear displacement is a fundamental concept in both mathematics and physics. It describes how angular movement translates into straight-line motion. This relationship is expressed mathematically as:

$$s=r\theta$$

where srepresents linear displacement, r is the radius of the cylinder, and θ is the angular displacement measured in radians. This equation shows that the distance traveled by the rolling sugarcane is directly proportional to both its radius and the angle through which it rotates. This relationship also illustrates the importance of measurement in understanding motion. By observing how far the sugarcane moves for each rotation, one can estimate the radius or the number of rotations required to cover a certain distance. Such reasoning reflects what Bishop (2004) described as measuring and explaining two of the fundamental mathematical activities present in all cultures. Even without formal calculations, farmers intuitively understand these relationships through repeated experience.

Furthermore, the rolling motion observed in this activity suggests an implicit understanding of efficiency and optimization. The choice to roll rather than drag the sugarcane indicates awareness of how motion can be achieved with minimal resistance. This relates to the concept of friction, where rolling reduces the contact area and thus lowers the opposing force. Although not expressed mathematically by the farmers, this principle aligns with physical laws governing motion, as described by Isaac Newton. This demonstrates that traditional practices often embody optimized solutions developed through practical experience.

Overall, the identification of mathematical concepts in the rolling sugarcane activity reveals the deep connection between culture and mathematics. The presence of geometric structures, rotational relationships, and measurement principles indicates that mathematical reasoning is inherently embedded in everyday practices. By formalizing these concepts, researchers can bridge the gap between informal knowledge and academic mathematics. This not only enriches mathematical understanding but also provides valuable opportunities for contextual learning, where students can relate abstract concepts to real-life experiences rooted in their own cultural environment.

Mathematical Model of Rolling Motion

The rolling motion of the sugarcane trunk can be rigorously modeled using the physical concept of rolling without slipping, a fundamental idea in classical mechanics. In this type of motion, the point of contact between the object and the ground is instantaneously at rest relative to the surface, even though the object as a whole is moving. This condition creates a precise relationship between rotational and translational motion. Such phenomena are central to mechanics as developed by Newton (1979) where motion is described through the interaction of force, mass, and acceleration.

In the context of the rolling sugarcane activity, this model assumes that the trunk behaves as an ideal solid cylinder. Although real sugarcane may have irregularities, this approximation allows the application of mathematical principles without significantly altering the nature of the motion. The rolling process observed in the field reflects a near-ideal case of rolling without slipping, as the trunk rotates while moving forward smoothly. This simplification is consistent with modelling practices in physics, where real objects are approximated to ideal forms for analytical purposes.

A key relationship in rolling motion is the connection between linear velocity and angular velocity. The velocity of the center of mass of the rolling cylinder is directly proportional to its angular velocity and radius, as expressed by the equation:

$$v=r\omega$$

In this equation, v represents linear velocity, ris the radius of the cylinder, and ωis the angular velocity. This relationship indicates that faster rotation results in greater forward movement, provided the radius remains constant. This relationship highlights the intrinsic link between rotation and translation in rolling motion. It implies that the motion of the sugarcane trunk can be fully described by either its linear or angular parameters. Such dual representation is a key feature of kinematics, allowing motion to be analyzed from different perspectives. According to Quimby (1950), understanding these relationships is essential for analyzing rigid body motion and energy transfer.

The rolling motion of the cylinder involves two forms of kinetic energy: translational kinetic energy and rotational kinetic energy. The translational kinetic energy corresponds to the motion of the center of mass and is given by:

$$E_t=1/2\ mv^2$$

Where mrepresents the mass of the cylinder and vits linear velocity. This component describes how the object moves through space as a whole. In addition to translational motion, the cylinder also possesses rotational kinetic energy due to its rotation about its central axis. This energy is expressed as:

$$E_r=1/2\ I\omega^2$$

Where I is the moment of inertia and ωis the angular velocity. The moment of inertia represents the resistance of the object to rotational motion and depends on the distribution of mass relative to the axis of rotation. For a solid cylinder, the moment of inertia is given by the following expression:

$$I=1/2\ mr^2$$

This formula indicates that the rotational resistance depends on both the mass and the square of the radius. Objects with larger radii or greater mass require more energy to achieve the same angular velocity. By substituting the expression for the moment of inertia into the rotational kinetic energy equation and combining it with translational kinetic energy, the total kinetic energy of the rolling cylinder can be derived as:

$$E=3/4\ mv^2$$

This result shows that the total energy is shared between translational and rotational components, with a specific proportion determined by the geometry of the object. The distribution of energy between these two components explains the efficiency of rolling motion. Unlike sliding motion, where energy is largely dissipated through friction, rolling motion conserves more energy by converting part of the motion into rotation. This reduces the overall resistance and allows the object to move more easily across the surface. As explained by Zwiebel &

Deliverable (2012), rolling motion is energetically more efficient because it minimizes energy loss due to frictional forces.

In the context of the Menggelek Tobu activity, this mathematical model demonstrates that traditional practices are grounded in principles of mechanical efficiency. Farmers intuitively utilize rolling motion to minimize effort, even without formal knowledge of physics equations. This finding reinforces the ethnomathematical perspective that sophisticated mathematical and physical reasoning can emerge from practical experience. By formalizing these observations through mathematical modelling, the activity can be used as a powerful educational tool to illustrate the integration of geometry, kinematics, and energy concepts in real-life situations.

Optimization of Rolling Force

One of the most important aspects of the rolling sugarcane activity is the optimization of mechanical effort, where farmers intuitively select rolling as the most efficient method for transporting heavy trunks. This choice reflects a practical understanding of how force can be minimized while maximizing movement efficiency. From a physics perspective, this behavior aligns with the principle that systems naturally evolve toward configurations requiring less energy expenditure. As explained by Newton (1979), motion is governed by forces and resistance, and reducing opposing forces leads to more efficient motion.

In the context of this activity, the force required to initiate and maintain rolling motion is primarily influenced by friction between the sugarcane trunk and the ground surface. Friction acts as a resisting force that opposes motion, and its magnitude depends on the nature of the surfaces in contact. The smoother the surface, the lower the friction, and consequently, the less force is required to move the object. This explains why farmers often prefer rolling sugarcane on relatively even ground to reduce resistance and effort.

The frictional force acting on the rolling sugarcane can be expressed mathematically as:

$$F=\mu N$$

Where F represents the frictional force, μis the coefficient of friction, and Nis the normal force. The coefficient of friction is a dimensionless quantity that characterizes the interaction between two surfaces, while the normal force represents the perpendicular force exerted by the ground on the object.

In this scenario, the normal force acting on the sugarcane trunk is equivalent to its weight, since the trunk rests on a horizontal surface. This relationship can be expressed as:

$$N=mg$$

Where m represents the mass of the trunk and g is the acceleration due to gravity. Substituting this expression into the friction equation provides a more specific form that applies directly to the rolling sugarcane system.

By combining these relationships, the frictional force becomes:

$$F=\mu mg$$

This equation clearly shows that the force required to overcome friction depends on both the mass of the sugarcane trunk and the coefficient of friction between the trunk and the ground surface. Heavier trunks require greater force, while smoother surfaces (lower μ) reduce the required effort.

This mathematical relationship highlights the importance of optimization in traditional practices. Farmers may not explicitly calculate these values, but through experience, they recognize that rolling is easier on certain surfaces and for certain trunk sizes. This reflects an implicit understanding of how variables such as mass and surface texture influence motion. According to Goldstein et al. (1980) such relationships form the basis for analyzing forces and motion in mechanical systems. Rolling motion significantly reduces energy consumption compared to sliding motion. When an object slides, friction acts across the entire contact surface, leading to substantial energy loss in the form of heat. In contrast, rolling motion limits contact to a small point or line at any given moment, drastically reducing frictional resistance. This difference explains why rolling requires less continuous force than dragging. As discussed by Halliday et al. (2013), rolling friction is typically much smaller than sliding friction, making rolling a more energy efficient mode of transport.

From an optimization perspective, the rolling method represents an effective strategy for minimizing mechanical work. Since work is defined as the product of force and displacement, reducing the required force directly decreases the total energy expended. This principle is consistent with the broader concept of efficiency in physics, where systems aim to achieve maximum output with minimal input. The Menggelek Tobu practice demonstrates how such optimization principles can emerge naturally from repeated practical experience.

The reduction in frictional resistance during rolling also contributes to smoother and more controlled motion. This allows farmers to transport sugarcane over longer distances with less fatigue and greater stability. The consistent rotation of the trunk ensures that no single point experiences prolonged contact with the ground, thereby minimizing wear and resistance. This behavior illustrates how geometric properties, such as the cylindrical shape of the trunk, directly influence mechanical efficiency. Overall, the optimization of rolling force in the Menggelek Tobu activity demonstrates that traditional knowledge systems incorporate sophisticated principles of physics and mathematics. By analyzing these practices through formal equations and models, it becomes evident that farmers utilize efficient strategies grounded in fundamental mechanical concepts. This finding reinforces the ethnomathematical perspective that cultural practices contain valuable scientific knowledge, which can be formalized and used as contextual learning resources in mathematics and physics education.

Optimization Graph of Rolling Energy

The analysis of energy optimization in the rolling sugarcane activity can be understood through the concept of mechanical work, which represents the amount of energy required to move an object over a certain distance. In classical mechanics, work is defined as the product of force and displacement. This concept is fundamental in explaining how energy is transferred during motion, as established by Isaac Newton and later formalized in energy-based analyses of motion. In the context of rolling sugarcane, this framework allows us to quantify the effort required to transport the trunk across a given distance.

The mechanical work required to move the sugarcane trunk can be expressed mathematically as:

$$W=F\cdot s$$

Where Wrepresents work, Fis the applied force, and sis the displacement. This equation indicates that the total energy required depends directly on both the magnitude of the force and the distance over which the object is moved.In the rolling sugarcane system, the dominant resisting force is friction, which opposes motion. As previously established, the frictional force can be expressed as:

$$F=\mu mg$$

Where μis the coefficient of friction, mis the mass of the trunk, and gis gravitational acceleration. By substituting this expression into the work equation, we obtain a more specific model for the energy required during rolling motion.

Substituting the frictional force into the work equation yields:

$$W=\mu mgs$$

This equation shows that the mechanical work required is directly proportional to displacement, mass, gravitational force, and the coefficient of friction. It highlights that heavier objects and rougher surfaces demand more energy to sustain motion. In rolling motion, displacement is closely related to rotational movement. Each complete rotation of the cylinder corresponds to a linear displacement equal to the circumference of its circular base. This relationship can be expressed as:

$$s=2\pi rn$$

Where r is the radius of the cylinder and nrepresents the number of rotations. This formula connects rotational motion with linear displacement, providing a crucial link in the modelling process.

By substituting this expression for displacement into the work equation, we obtain a comprehensive model of rolling energy:

$$W=2\pi\mu mgrn$$

This equation indicates that the mechanical work required depends on several variables: the coefficient of friction, the mass of the object, gravitational acceleration, the radius of the cylinder, and the number of rotations. A key implication of this model is that the required mechanical energy increases linearly with the radius of the cylinder when other variables remain constant. This means that larger sugarcane trunks, which have greater radii, require more energy to be rolled over the same distance. This linear relationship is significant because it allows predictions about energy requirements based on geometric properties. According to Michael & Ekpe (2017) such linear dependencies are characteristic of many mechanical systems where proportional relationships govern motion.

The graphical representation of this relationship provides further insight into the optimization of rolling motion. In the optimization graph, the horizontal axis represents the radius of the cylinder, while the vertical axis represents the mechanical work or energy required. The resulting graph forms a straight line, indicating a direct proportional relationship between radius and energy. This linear trend simplifies analysis and helps in understanding how changes in physical dimensions affect energy consumption.

From a practical perspective, this graph explains why farmers may prefer rolling smaller or moderately sized trunks rather than excessively large ones. While rolling reduces friction compared to dragging, increasing the size of the trunk still increases the total energy required. This demonstrates that optimization involves balancing multiple factors, including size, weight, and surface conditions. As noted by Halliday et al. (2013) understanding such relationships is essential for analyzing efficiency in mechanical systems.

Overall, the optimization graph of rolling energy illustrates how mathematical modelling can reveal the underlying efficiency of traditional practices. The linear relationship between radius and energy provides a clear and interpretable framework for understanding the mechanics of rolling motion. This analysis not only deepens the scientific understanding of the Menggelek Tobu activity but also reinforces the idea that cultural practices embody practical optimization strategies. By translating these insights into mathematical form, the activity can serve as a powerful educational tool for teaching concepts of work, energy, and proportional relationships in a contextual and meaningful way.

Ethnomathematical Interpretation

The findings of this study demonstrate that traditional agricultural practices, particularly the Menggelek Tobu activity, contain implicit mathematical reasoning that can be systematically analyzed through ethnomathematical frameworks. This reinforces the view that mathematics is not confined to formal institutions but is deeply embedded in cultural practices and daily life. D'Ambrosio (1985) emphasized that mathematical knowledge develops through human interaction within specific cultural contexts, making it a product of social experience rather than an isolated abstract system.

The rolling sugarcane activity reflects several interconnected mathematical principles, including geometry, mechanics, and optimization. The cylindrical shape of the sugarcane trunk corresponds to geometric concepts, while its motion involves principles of kinematics and force. Additionally, the efficiency achieved through rolling demonstrates optimization strategies in minimizing effort. These overlapping concepts illustrate that cultural practices often integrate multiple domains of mathematics simultaneously, forming a holistic system of knowledge.

An important aspect of this interpretation is that these mathematical ideas are not explicitly taught within the community. Instead, they emerge through experiential learning, where individuals acquire knowledge by observing, practicing, and refining their techniques over time. This process reflects what Lave (1991) describes as situated learning, in which knowledge is constructed through participation in social and cultural activities. In this context, farmers develop an intuitive understanding of motion, balance, and efficiency without formal mathematical instruction.

This form of implicit knowledge highlights the distinction between formal and informal mathematics. While formal mathematics is expressed through symbols, formulas, and structured instruction, informal mathematics exists in practical activities and everyday problem-solving. The Menggelek Tobu activity demonstrates how informal mathematical knowledge can be highly functional and effective, even without formalization. This supports the idea that mathematical competence can develop outside traditional educational settings.

The interpretation of this activity aligns closely with the ethnomodelling framework proposed by (Rosa & Orey, 2011). They argue that cultural practices can be translated into formal mathematical models, thereby bridging the gap between local knowledge and academic mathematics. Through ethnomodelling, the rolling sugarcane activity can be understood as a system involving geometric representation, rotational motion, and mechanical forces, all of which can be expressed using mathematical language.

Furthermore, this analysis demonstrates that cultural practices serve as valuable contexts for exploring mathematical knowledge. Activities such as agriculture, construction, and craftsmanship often involve problem-solving processes that require measurement, estimation, and optimization. By examining these activities, researchers can identify mathematical structures that may not be immediately visible. This perspective expands the scope of mathematics beyond textbooks and classrooms, recognizing its presence in diverse cultural settings.

The findings also support the framework proposed by (Bishop, 2004), who identified universal mathematical activities such as measuring, designing, and explaining as inherent in all cultures. In the Menggelek Tobu activity, farmers engage in these activities when they determine how to position the sugarcane, apply force, and control its movement. These actions demonstrate that mathematical thinking is an integral part of human behavior, even when it is not formally recognized. In addition, the ethnomathematical interpretation highlights the role of cultural knowledge in developing efficient and adaptive solutions. The choice to roll sugarcane rather than drag or lift it reflects an understanding of how to minimize effort and maximize efficiency. This indicates that traditional practices are often the result of long-term experimentation and refinement, leading to optimized methods that align with scientific principles. Such insights challenge the perception that advanced knowledge is only produced in formal scientific contexts.

By examining everyday activities such as the rolling of sugarcane, researchers can uncover mathematical structures that remain hidden within cultural traditions. This process not only enriches academic understanding but also validates the intellectual contributions of local communities. It demonstrates that cultural practices are not merely routines but are embedded with logical reasoning and problem-solving strategies that can be analyzed and appreciated within a mathematical framework. Overall, the ethnomathematical interpretation of the Menggelek Tobu activity provides a deeper understanding of how mathematics operates within real-life contexts. It highlights the interconnectedness of culture and mathematics, showing that knowledge is both socially constructed and practically applied. By bridging informal cultural knowledge with formal mathematical concepts, this approach offers valuable insights for both research and education, promoting a more inclusive and contextualized understanding of mathematics.

Educational Implications

Integrating ethnomathematical contexts into mathematics education offers significant pedagogical benefits, particularly in creating learning experiences that are meaningful, relevant, and culturally responsive. This approach shifts the perception of mathematics from a purely abstract discipline into a living body of knowledge rooted in human activity. As emphasized by D'Ambrosio (1985), mathematics should be understood as a cultural product, and therefore its teaching must reflect the cultural realities of learners. In this sense, ethnomathematics becomes a powerful framework for bridging formal education with students lived experiences.

First, contextual learning enables students to connect abstract mathematical concepts with real-world experiences. When students encounter mathematical ideas within familiar cultural practices, such as the rolling sugarcane activity, they are more likely to understand the meaning behind the concepts rather than simply memorizing formulas. This aligns with the theory of meaningful learning proposed by Muamanah (2020), which states that new knowledge is more effectively learned when it is connected to prior knowledge. By linking mathematical concepts to everyday activities, educators can facilitate deeper conceptual understanding.

Furthermore, contextual learning enhances student engagement and motivation. Students often perceive mathematics as difficult or disconnected from their lives, which can reduce interest in learning. However, when mathematical principles are demonstrated through culturally relevant activities, students become more curious and actively involved in the learning process. Research by Ozdem-Yilmaz & Bilican (2025) highlights that learning is more effective when students actively discover concepts through meaningful contexts rather than passively receiving information. Second, ethnomathematics promotes cultural awareness by highlighting the intellectual contributions of local communities. Recognizing that traditional practices contain mathematical knowledge helps students develop respect for their cultural heritage. This is particularly important in multicultural societies, where education plays a role in preserving and valuing diversity. According to Rosa & Orey (2011) integrating cultural contexts into mathematics education fosters a sense of identity and belonging among students.

In addition, this approach challenges the dominance of purely Western perspectives in mathematics education by recognizing multiple ways of knowing. Ethnomathematics validates indigenous knowledge systems as legitimate sources of mathematical understanding. This perspective supports inclusive education by ensuring that students from different cultural backgrounds see their experiences reflected in the curriculum. Such inclusivity contributes to a more equitable learning environment and encourages participation from diverse groups of learners.

Third, ethnomathematical approaches encourage interdisciplinary learning by linking mathematics with other fields such as cultural studies, physics, and engineering. The rolling sugarcane activity, for example, integrates geometric concepts (cylinders), physical principles (motion and force), and practical problem-solving strategies. This aligns with the interdisciplinary learning framework proposed by Gardner (1993) which emphasizes that knowledge is best understood when connected across different domains. Through such integration, students can develop a more comprehensive understanding of how mathematics functions in real-world contexts.

Moreover, ethnomathematics supports the development of higher-order thinking skills, including critical thinking, problem-solving, and analytical reasoning. When students are encouraged to analyze cultural practices and identify underlying mathematical structures, they engage in processes of abstraction, modeling, and interpretation. These skills are essential for understanding complex problems and applying mathematical knowledge in diverse situations. This approach moves beyond procedural learning toward deeper cognitive engagement.

The rolling sugarcane activity can therefore serve as a powerful contextual learning resource for teaching topics such as cylindrical geometry, rotational motion, and optimization problems. By incorporating this activity into classroom instruction, teachers can create lessons that are not only academically rigorous but also culturally meaningful. Overall, the integration of ethnomathematics into education enhances conceptual understanding, strengthens cultural identity, and promotes interdisciplinary learning, making mathematics more accessible and relevant to students' lives.

Geometric Model of Sugarcane

The geometric modeling of the sugarcane trunk in the Menggelek Tobu activity provides a clear example of how natural objects can be represented using formal mathematical structures. Observationally, the sugarcane trunk exhibits characteristics similar to a cylinder, including a circular cross-section and a relatively uniform radius along its length. This geometric regularity allows the trunk to roll smoothly on the ground, making it suitable to be modeled as an ideal cylinder for analytical purposes. Such abstraction is a common approach in mathematics, where complex real-world objects are simplified into ideal forms to facilitate analysis.

From a mathematical perspective, a cylinder is defined as a three-dimensional solid bounded by two parallel circular bases and a curved lateral surface. The primary parameters defining a cylinder include radius, diameter, and height (or length). By approximating the sugarcane trunk as a cylinder, we can apply geometric formulas to describe its properties, such as volume, surface area, and circumference. This process demonstrates how cultural practices can be linked to formal mathematical reasoning through modeling.

One of the key formulas used in this geometric model is the volume of a cylinder:

$$V=\pi r^2 L$$

Where r represents the radius of the circular base and L represents the length of the sugarcane trunk. This formula allows us to estimate the physical capacity or size of the trunk, which can be useful in agricultural contexts such as measuring yield or storage. In addition to volume, the circumference of the circular base plays an important role in understanding rolling motion. The circumference determines the distance traveled during one complete rotation and is given by:

$$K=2\pi r$$

This relationship connects geometric properties with kinematic behavior, showing how shape influences motion. Furthermore, the geometric model also supports the analysis of rotational motion through the relationship:

$$s=r\theta$$

Which links linear displacement (s) with angular displacement (θ). This demonstrates that geometry is not only static but also plays a role in dynamic processes. Overall, the geometric model of the sugarcane trunk highlights the integration of shape, measurement, and motion in a single framework. This reinforces the idea that mathematical concepts are deeply embedded in everyday cultural practices and can be systematically analyzed to support both scientific understanding and educational applications.

Table. 1 Analysis of Mathematical Concepts

Cultural Activity	**Mathematical Concept**	**Matematical Representation**
Rolling sugarcane trunk	Cylinder geometry	$V = \pi r^2 L$
Shape of sugarcane trunk	Circular cross-section	$K = 2\pi r$
Rolling Motion	Angular displacement	$s = r\theta$
Pushing Sugarcane	Friction Force	$F = \mu mg$
Rolling Energy	Mechanical Work	$W = F \cdot s$

Table. 2 Educational Context Integration

Cultural Context	**Mathematics Topik**	**Learning Activity**
Rolling sugarcane	Geometry (Cylinder)	Identify radius, diameter, and volume of sugarcane
Sugarcane movement	Trigonometry Rotation	Analyze relationship between angle and displacement
Rolling process	Mechanics (Physics-Math)	Calculate friction force and motion efficiency

Agricultural practice	Measureement	Estimate length, distance, and number of rotations
Local cultural activity	Mathematical Modeling	Transform real activity into mathematical equations

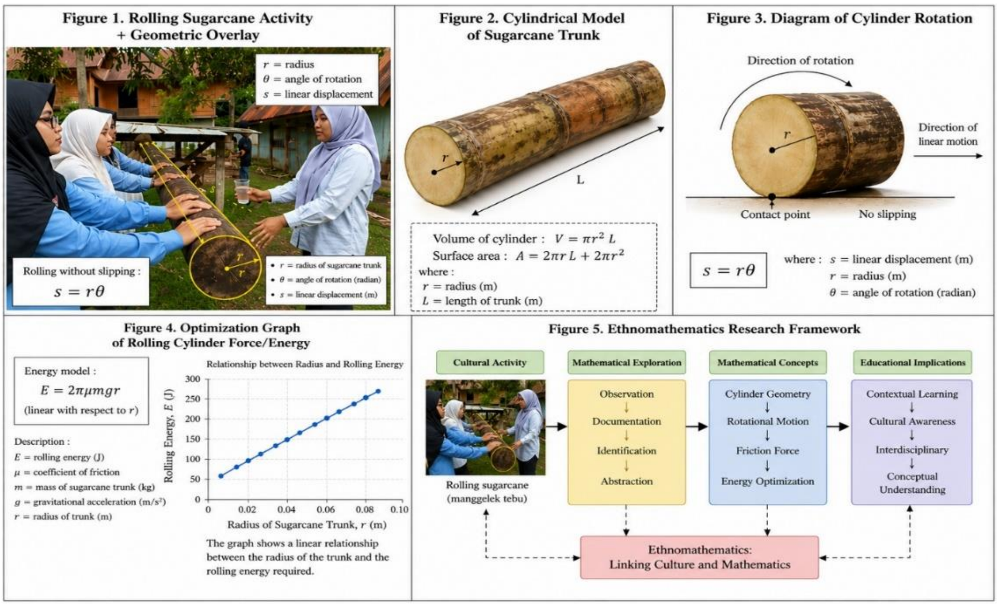

Figure. 1 Ethnomathematical Representation of Manggelek Tobu: From Cultural

Educational Implications

The rolling sugarcane activity Menggelek Tobu offers significant potential as a contextual learning resource in mathematics education. By integrating this cultural practice into classroom instruction, abstract mathematical concepts can be connected to real-life experiences that are familiar to students. This approach aligns with the ethnomathematical perspective proposed by D'Ambrosio (1985), which emphasizes that mathematics should be taught as a human activity embedded in culture. When students recognize mathematical ideas in everyday practices, learning becomes more meaningful, relevant, and engaging.

In the context of teaching cylinder geometry, the sugarcane trunk provides a concrete and observable example of a three-dimensional geometric object. Students can directly explore properties such as radius, diameter, height (length), surface area, and volume through real objects rather than abstract diagrams. This hands-on approach supports conceptual understanding, as students are able to visualize and manipulate physical representations. According to Jean Piaget, learners construct knowledge more effectively when they interact with tangible objects, particularly in the transition from concrete to formal operational thinking.

The activity also serves as an effective context for teaching rotational motion, a fundamental concept in mathematics and physics. The rolling movement of the sugarcane trunk illustrates the relationship between linear displacement and angular displacement, expressed by the equation $s=r\theta$. By observing and analyzing this motion, students can develop a deeper understanding of how rotational systems work. This experiential learning approach is consistent with the ideas of Jerome Bruner, who emphasized that learning is most effective when students actively construct knowledge through discovery and interaction with their environment.

Furthermore, the rolling sugarcane activity provides a meaningful context for exploring optimization problems, particularly those related to energy and efficiency. The mathematical model $E=2\pi\mu mgr$ demonstrates how energy requirements change based on physical variables such as radius and mass. Students can analyze how to minimize effort while maximizing efficiency, which is a key concept in applied mathematics. This type of problem-solving encourages critical thinking and analytical skills. As noted by George Polya, effective mathematics learning involves understanding problems, developing strategies, and applying reasoning to find optimal solutions.

Overall, integrating the rolling sugarcane activity into mathematics education supports a holistic and interdisciplinary approach to learning. It connects mathematical concepts with physics and cultural knowledge, creating a richer learning experience. Additionally, it promotes cultural awareness by highlighting the value of local traditions as sources of knowledge. This aligns with the work of Rosa & Orey (2011), who argue that ethnomathematics enhances both cognitive understanding and cultural identity. Therefore, the use of culturally grounded contexts such as Menggelek Tobu can significantly improve student's engagement, comprehension, and appreciation of mathematics.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the traditional activity of rolling sugarcane Menggelek Tobu embodies rich and meaningful mathematical structures that extend beyond simple observation. What initially appears as a routine agricultural practice is, in fact, a complex system involving geometric form, motion, force, and energy. The findings confirm that mathematics is not confined to formal academic settings but is deeply embedded in cultural practices and everyday human activities.

From a geometric perspective, the sugarcane trunk can be effectively modeled as a cylinder, allowing the application of fundamental concepts such as radius, length, volume, and circumference. This abstraction demonstrates how natural objects can be represented mathematically to facilitate analysis. The cylindrical structure is not only a descriptive feature but also a functional one, as it directly influences the efficiency of rolling motion.

In terms of motion, the study highlights the relationship between linear displacement and angular displacement, expressed through the equation $s=r\theta$. This relationship shows how rotational movement translates into forward motion, providing a clear example of the integration between geometry and kinematics. The rolling process reflects the principle of rolling without slipping, which ensures efficient movement with minimal energy loss.

The analysis of forces further reveals that friction plays a crucial role in the rolling process. The equation $F = \mu mg$ explains how the required force depends on the mass of the sugarcane and the characteristics of the surface. The study demonstrates that rolling significantly reduces friction compared to sliding, which explains why it is the preferred method for transporting heavy objects in this cultural context.

Additionally, the concept of energy optimization is central to understanding the efficiency of the rolling sugarcane activity. The derived energy model $E = 2\pi\mu mgr$ shows a linear relationship between the radius of the cylinder and the energy required for movement. This finding indicates that physical dimensions directly influence energy consumption, and it reflects an intuitive understanding among farmers in selecting efficient methods of work.

From an ethnomathematical perspective, this study reinforces the idea that cultural practices contain implicit mathematical reasoning that can be formalized through scientific analysis. The activity of Menggelek Tobu demonstrates how knowledge is developed through experience, observation, and practical necessity. This supports the view that mathematics is a cultural product that evolves within specific social contexts.

The educational implications of this study are significant. By integrating cultural contexts such as rolling sugarcane into mathematics education, teachers can create more meaningful and engaging learning experiences. Students are able to connect abstract concepts with real-world applications, which enhances conceptual understanding, critical thinking, and motivation. Furthermore, this approach promotes cultural awareness and appreciation, strengthening students' connection to their local heritage.

In conclusion, this study contributes to the development of ethnomathematics by demonstrating that dynamic cultural activities can be modeled using formal mathematical concepts. It highlights the importance of bridging informal knowledge and academic mathematics, and it opens opportunities for future research to explore other cultural practices through similar approaches. Ultimately, integrating ethnomathematical perspectives into education can lead to more inclusive, contextual, and meaningful mathematics learning.

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