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Geometry and Measurement Concepts in the Process of Making *Kiling Gedhe* in Banyuwangi

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ABSTRACT

Kiling (or *panjer kiling*) is a local cultural artifact from Banyuwangi Regency, consisting of a windmill constructed from bamboo and wood. It is typically used to deter pests and indicate wind direction. This study aims to identify the ethnomathematical elements, specifically those related to geometry and measurement, present in the construction process of a *kiling gedhe*. The research employs a qualitative, ethnographic approach. Two informants were selected purposively based on their expertise in crafting *kiling gedhe*. Data were collected through observation, interviews, and documentation, and then triangulated across sources. The data were analyzed qualitatively, focusing on indicators of mathematical concepts in geometry and measurement. The study reveals that constructing a *kiling gedhe* incorporates various mathematical concepts, including non-standard units of measurement (*depa* and *kilan*); obtuse angles; two-dimensional shapes such as squares and rectangles; and three-dimensional forms such as rectangular prisms, cylinders, and truncated cones. These findings could be integrated into mathematics education as a source for culturally based, contextual learning.

Keywords: Banyuwangi; elements of geometry and measurement; ethnomathematics; *kiling gedhe*; mathematical concepts

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INTRODUCTION

Banyuwangi is a regency in Indonesia characterized by a diverse range of cultural traditions. Located at the eastern tip of the island of Java, it is part of the province of East Java. The indigenous people of Banyuwangi are known as the *Osing* tribe. In general, the Osing tribe possesses a rich cultural heritage, including various forms of performance and entertainment such as *gandrung*, *seblang*, *kebo-keboan*, *jaranan butho*, *musik lesuk*, *gamelan Banyuwangi*, *patrol*, and *angklung caruk* (Selfana et al., 2023). Furthermore, there are also cultural elements that are not intended for entertainment, such as traditional housing, the practice of determining auspicious days, specific customs regarding trade and commerce, agricultural practices, and more.

One aspect of Banyuwangi's culture, rooted in agricultural practices, is the *kiling* – a windmill crafted from wood and/or bamboo by the Osing people, which is closely linked to their farming traditions. Literature on the kiling remains quite limited, particularly from the last decade. The *kiling* is considered a form of agrarian architectural heritage that continues to thrive within the community; it is rich in meaning and life symbolism, while reflecting local knowledge and skills passed down through generations (Sodiqin, 2018). Furthermore, it is explained that the *kiling* (also known as *panjer kiling*), consists of a windmill mounted on a support structure (*panjer*) – typically a large bamboo pole – erected in rice fields at a height of five to ten meters. In some cases, the kiling is attached to a large tree within the rice fields; as the wind blows, it produces a loud sound, which serves to deter birds or simply provides entertainment (Rubiono & Anam, 2022; Taniardi et al., 2022).

Based on their primary materials, *kiling* are categorized into two types: *kiling slurutan*, made from bamboo, and *kiling gedhe*, made from wooden slats (Rubiono & Anam, 2022). Information and observations gathered by the researchers between September and December 2025 indicate that kiling makers are generally more skilled at crafting *kiling gedhe* (no makers of *kiling slurutan* were identified). Consequently, this study is limited to the production of *kiling gedhe*.



(a) (b)

Figure 1. (a) *Kiling Gedhe*, Comprising the *Lanang* and *Wadon* Sides (Author's Documentation); **(b)** *Panjer Kiling*, Consisting of the *Panjeran* (Support), the *Kiling* itself, and the *Buntut* (Tail) (Saksono, 2022b)

Research on the *kiling* conducted by Mardiastuti (2016) indicates that the best *kiling gedhe* (large kiling) are crafted from *cempogo* wood, though *mangir* or *loloan* wood can also be used. It is further explained that the *kiling* resembles a long clock hand and features two sides (right and left), with one side being thinner and curved. These two sides represents the *lanang* (male) and *wadon* (female) components: the *lanang* side is long and slightly curved – which allows it to produce sound when mounted on the *panjer* (support pole) – while the *wadon* side is short and straight (Saksono, 2022a), as shown in **Figure 1 (a)**. The center of the *kiling* contains components known as *selut*, *teblok* and *soh*, which serve as an axis when the *kiling* is mounted on the *panjeran* (Mardiastuti, 2016). The *panjer kiling* assembly consists of

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three main parts: the *panjeran* (support pole), the *kiling* itself, and the *buntu*t (tail) (Banafsah, 2021), as illustrated in **Figure 1 (b)**.

In previous research, the *panjer kiling* was explored for its potential as a source of renewable energy, utilizing small-scale wind power (Rubiono & Anam, 2022). Beyond this, no other studies on the kiling in Banyuwangi have been identified. Preliminary observations by the researchers revealed the presence of geometric forms in the *kiling* structure, such as rectangular wooden beams and cylindrical bamboo poles. Interviews with a kiling maker further indicated that specific measurements are employed during its construction. These measurements are still determined using traditional methods – for instance, by using the *depa* (a unit of measurement based on the span of a person's outstretched arms). Based on these initial findings, it can be concluded that the kiling of Banyuwangi incorporates mathematical concepts that could be applied in educational settings.

Mathematical concepts found within cultures are generally known as ethnomathematics. The term was introduced in 1977 by the Brazilian mathematician D'Ambrosio (Hariastuti et al., 2022), who defined ethnomathematics as mathematics practiced among various cultural groups – such as specific communities, labor groups, children of certain age ranges, or even professional classess. The concept aims to demonstrate the diverse ways in which mathematics can be interpreted, taking into account the mathematical knowledge that develops across different sectors of society and the various cultures that encompass mathematical practices (Abroriy, 2020).

Ethnomathematics acknowledges the existence of diverse approaches applied within the lives or activities of a community (Jayanti & Puspasari, 2020). Consequently, it is important to explore and identify ethnomathematics as a means to enrich mathematics learning resources – particularly for students who lack access to information technology (IT). Nevertheless, it is also possible for ethnomathematics to be integrated with IT to develop creative and innovative mathematics learning resources or media.

Various ethnomathematical studies exploring cultural practices in agriculture have been conducted. An exploration of farming culture in Jombang Regency reveals the presence of concepts such as patterns, parallel lines, and spatial regularity during the harvesting of rice panicles; grouping, quantity estimation, ratios, and arithmatic operations during the bundling of the harvest; load and capacity, addition, and estimation during the transport of the harvest to the milling site; as well as frequency, estimation, and volume during the threshing of the grain (Fatmawati et al., 2026). An exploration of shallot cultivation in Brebes Regency reveals the presence of concepts related to measurement, geometry, and arithmetic within agricultural activities, the use of tools, and traditional units of measurement (Putri & Kusno, 2025). Ramadani et al. (2025) explored the activities of tobacco farmers in Jember Regency, finding that geometric concepts, measurement, and spatial reasoning are applied in tasks such as land division, the arrangement of planting patterns, the construction of irrigation channels, and the use of traditional tools. In Banyuwangi, an exploration was also conducted on the maize cultivation system in the Papring area, Kalipuro District (Darmawan & Hariastuti, 2025). The findings indicate that this maize cultivation system incoporates concepts involving whole number operations, ratios, fractions, time, social arithmetic, measurement, two-dimensional and three-dimensional shapes, probability, and sets.

Ethnomathematical exploration has also been specifically applied to agricultural tools. Viranikita dan Septianawati (2025) explored traditional agricultural tools in Kubu Raya Regency, West Kalimantan. Their findings reveal the presence of geometric and measurement concepts in tools such as the *ani-ani*

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(hand-held rice harvester), *bakul* (basket), *tampah* (winnowing tray), *lumpang* (mortar), and *alu* (pestle). An exploration of traditional agricultural tools in Kampar regency identified the concept of a circle in the *ambuong* (basket), a square in the *nyiru* (winnowing tray), and isosceles trapezoid in the *losuong* (mortar) (Zulfah et al., 2023). Research in Hutamanik Village, Sumbul Regency, uncovered concepts of measurement, proportion, and geometry in tools including the *gendang air* (water drum), coffe grinder, shaving tool, saw, hoe, and sickle (Padang & Lubis, 2023). A study by Akbar et al. (2021) on traditional agricultural tools in Pinrang Regency identified the concept of a kite shape in the *Teda*', a rectanglein the *Passampa*', and a circle in the Pattapi.

The findings from research on agricultural processes and equipment indicate that there has been no exploration of agricultural tools incorporating wind vanes – a gap that exists across all regions. This gives the present study a sense of novelty regarding its subject matter. Furthermore, this research focuses on the manufacturing process, an aspect that has not been addressed in previous studies.

Based on the description above, this study aims to identify the mathematical practices involved in the creation of *kiling gedhe* in Banyuwangi. This identification is grounded in mathematical concepts found within the Kurikulum Merdeka (Independent Curriculum), specifically those pertaining to the elements of geometry and measurements. Conducting this research is significant for enriching the study of traditional agricultural tools in Banyuwangi, as well as for contributing findings in the field of ethnomathematics that can be implemented in school-based instruction.

METHOD

Research Design and Setting

This study aims to explore the crafting of *kiling gedhe* in Banyuwangi and to identify the ethnomathematics embedded within it. The research was conducted from September 2025 to March 2026 in the Glagah and Licin districts – areas selected because they are still home to *kiling gedhe* makers.

This study is qualitative in nature and employs an ethnographic approach. An ethnographic approach was chosen because the research aims to describe a specific culture (Mahendra et al., 2024) – namely, the creation of the *kiling gedhe*. Subsequently, the ethnomathematics embedded within the cultural practice of making the *kiling gedhe* is identified. This identification focuses specifically on the elements of geometry and measurement, as outlined by the Ministry of Basic and Secondary Education (Kemendikdasmen, 2025). These two elements were selected based on the forms and structures visible in the *kiling gedhe*.

In accordance with the characteristics of qualitative research, the researcher serves as the primary instrument, supported by observation and interview guides. Furthermore, data collection is supplemented by documentation methods to obtain data in the form of images and audio. The indicators within the observation and interview guides focus on the tools and materials used, as well as the production process of the kiling gedhe. The specific questions asked may evolve based on the situation during data collection, while remaining within the framework of the established interview guide indicators.

The following is the research workflow that has been carried out.

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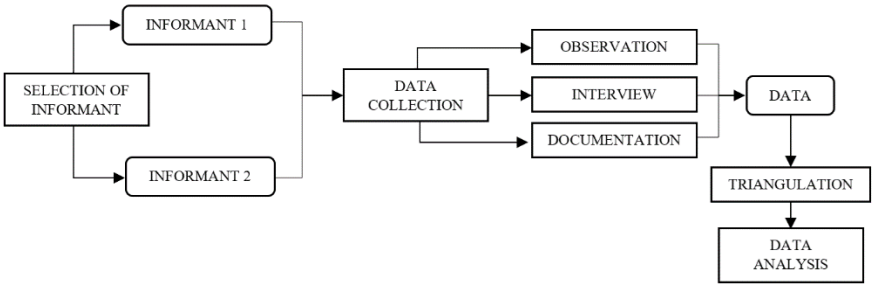

Figure 2. Research Flow

Participants, Instruments, and Procedures

Informants were selected purposively, with the requirement that they possess the skills to craft *kiling* and have practiced this craft for at least 10 years. This selection process identified three informants who met the established criteria. However, during the data collection phase, it was not possible to gather data from one of these informants, as they could not secure the specific materials required for crafting *kiling gedhe* (as the informant adheres to strict standards regarding the materials used). Consequently, two informants were ultimately selected; they were deemed to provide sufficient and in-depth data, as they were able to comprehensively articulate the cultural process behind the creation of *kiling gedhe*. Data obtained from these two informants were then triangulated to validate the findings.

Data Analysis

The data obtained from the two informants were triangulated, and the results served as the basis for data analysis, which was conducted through the following stages: data reduction, data presentation, and conclusion. The triangulated data were categorized using the following codes: A for the tools used to make *kiling*, B for the materials used to make *kiling*, and C for the process of making *kiling*. Subsequently, the data were presented in the form of descriptions and images. Conclusion were drawn based on indicators of mathematical concepts within the elements of geometry and measurement (Kemendikdasmen, 2025).

RESULTS

This study was conducted to explore the *kiling gedhe*, which measures over three *depa* in total. This length consists of two *depa* made of wood, while the remaining one depa serves as a *panjeran* made of bamboo. Data were collected from two informants. The first informant (I_1), a resident of Mangli village, works as farmer and carpenter; he frequently crafts *kiling gedhe* for his personal collection as well as for orders from neighboring villages. The second informant (I_2) works as a trader of jackfruit and other agricultural produce; he is an enthusiast of *kiling* and creates *kiling gedhe* for his own personal collection.

The results of source triangulation indicate that the materials required by both informants to construct a *kiling gedhe* include wood, bamboo, and rope. I_2 also uses paint to coat their *kiling*. Wood serves as the primary material for constructing a *kiling gedhe*. The wood selected for this purpose must come from the main trunk of a specific, strong tree species; it must be straight, free of large branches in the sections intended for use, resistant to pests, and capable of producing a loud, resonant sound once the *kiling* is

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completed. The following is an explanation from I_1 and I_2 regarding the use of wood as a material for the *kiling*.

P *: Sak derenge damel kiling, nyiapaken nopo mawon, man?*
(what needs to be prepared before making a *kiling*, Uncle?)
I_1 *: Yo nyiapaken badene iku (kayu)*
(You have to prepare the *bade* – the wood, that is)
P *: Nggeh kayu...kajenge dingge niku nopo mawon jenise?*
(what kinds of wood are used?)
I_1 *: Yo kayu laban, langsat, loloan, yo kayu ketimo iku, mangir, rambutan yo keneng. Kayu cempogo yo apik iku*
(*laban, langsat, loloan, ketimo, mangir*, and even *rambutan* wood can be used. *Cempogo* wood is also good)
P *: Nopo'o mboten ndamel kayu cempogo kang sae niku?*
(why not used that *cempogo* wood, since it's so good?)
I_1 *: Yo...sak iki iku angel golekane*
(well...these days, it's hard to find)

According to I_1, *cempogo* wood is a suitable type for the construction of *kiling*. However, as this type has become difficult to obtain, other woods are used instead, such as: *laban, langsat, ketimo, mangir,* and *rambutan*. I_2 provides a similar account, though specifically mentioning the use of *mangir, cempogo, lolohan, uris-urisan*, and *ketimo* woods.

P *Yang dibuat kiling kayu apa saja, pak? Yang paling bagus?*
(What types of wood can be used to make a *kiling*, sir? Which ones are the best?)
I_2 *Yang paling bagus ya mangir, dua itu cempogo, tiga lolohan, empat uris-urisan, terus kelima ketimo. Nah, itu yang paling disukai para ahli-ahli pembuat kiling.*
(The best is *mangir*, second is *cempogo*, third is *lolohan*, fourth is *uris-urisan*, then fifth is *ketimo*. Well, that's what the *kiling* experts like the most.)

The selection of this wood is supported by Mardiastuti (2016), who explains that the best *kiling gedhe* can be crafted using *cempogo* wood, though *mangir* or *loloan* wood may also be used. Furthermore, it is noted that these types of wood must be sourced from trees that are straight, free from twists, and devoid of any branches or twigs along the section of the trunk intended for use.

Wood is used to construct the body of the *kiling gedhe,* which consists of a *lanang* side, a *wadon* side, and a *tombongan*. The *tombongan* is a protruding, elongated section located in the center of the *kiling*. The *lanang* side features a curve and is approximately one *kilan* (handspan) longer than the *wadon* side. The *lanang* side is crafted to be thinner, ensuring it remains balanced with the *wadon* side despite the difference in length.

In addition to forming the main body of the *kiling*, wood is also used to craft the *teblok*, as well as the *selut* and *tutup* (fittings/covers). A *teblok* is a wooden board with a width matching that of the *kiling* and a length roughly equivalent to that of the *tombongan*. Both ends of the *teblok* are attached to the center of the *kiling* and shaped into tapered points, featuring at least six sides and six corners. It can be seen in **Figure 3 (a).** On the side where the *teblok* is attached, there is a *pliring* – a surface of the *kiling* that is beveled or sloped toward one side, as shown in **Figure 3 (b)**. While *pliring* can be found on both the *wadon* and *lanang* sides of the *kiling*, they are more prevalent on the *lanang* side, particularly along the *luk* (the curves or undulations of the *kiling*). Once the wood has dried and been smoothed down, the *luk* (curves) can be carved into the *lanang* side of the *kiling*. Both the *teblok* and the main body of the *kiling*

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feature a square-shaped central opening – with four equal sides meeting at 90° angles – which is used to accommodate the *kolok* (Mailani et al., 2024).



(a) (b)

Figure 3. **(a)** *Kolok* that has been installed on the *Teblok* and tied with *Soh*, **(b)** *Pliringon* the *Lanang* Side of *Kiling* (Researcher's Documentation)

A *kiling gedhe* also requires bamboo for the construction of the *kolok* and the *panjeran.* The *kolok* is a small bamboo segment positioned at the center of the *kiling*, serving as a mounting point for its various components. The *panjeran*, meanwhile, is a dedicated bamboo pole used to support and mount the *kiling*. The *kolok* is crafted from *jajang watu* bamboo – or another suitable variaety – provided it meets specific criteria: it must have straight internodes with a small diameter (approximately 3 - 5 cm) and be harvested when sufficiently mature and dry to ensur durability and resistance to breakage. The inner diameter of the bamboo segment must exceed 12 mm to accommodate the central shaft (an iron rod, typically 12 mm in diameter) used to mount the *kiling*. The *kolok* functions as a base for attaching the *selut* and *tutup*. It is cut to a length of less than one *jengkal* (a span of a hand), with both ends shaved down to form a rectangular block – featuring four sides at 90° angles and a square base (Diniyati et al., 2022) – allowing it to pass through the openings in the *kiling* or *teblok*, while ensuring that the selut and tutup can be fitted precisely.

The *selut* is the central component of a *kiling*, which is connected to a *panjeran* to allow the *kiling* to rotate. Made of wood, the *selut* is essentially tubular in shape, featuring attachments on both sides and a small hole in its center. Its tubular form is evident from its top and base, both of which are circular with a diameter of approximately 8 cm, as shown in **Figures 4 (a)** and **Figure (b)**, as well as **Figure 5 (a)**. This is consistent with the definition provided by Simanjuntak et al. (2022), who describe a cylinder (tube) as a three-dimensional geometric solid with a top and a base that are both circular and possess the same diameter.



(a) (b) (c) (d)

Figure 4. (a) Upper Cross-Section of the *Selut*, **(b)** Lower Cross-Section of the *Selut*, **(c)** Upper Cross-Section of the *Tutup Selut*, and **(d)** Lower Cross-Section of the *Tutup Selut* (Researcher's Documentation)

The hole in the middle of the *selut* is the place where the *kinci* (iron rod that attaches the *kiling* to the *panjeran*) is inserted. So, the hole in the *selut* functions as a place to install or hang the *kiling* on the *panjeran.*

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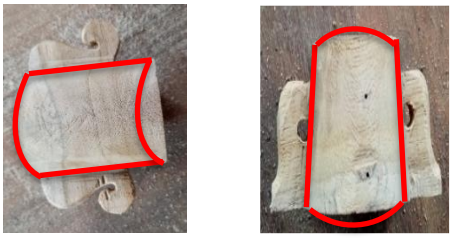

(a) (b)

Figure 5. (a) *Selut and* **(b)** *Tutup Selut (Researcher's Documentation)*

The *selut* is paired with a *tutup selut* (or simply *tutup*), which is shaped like a truncated cone with a hole in the center. This truncated cone shape is evident from the circular top and bottom surfaces of the *tutup selut*; the top surface has a diameter of 5 cm, while the bottom surface has a diameter of 4 cm. This is illustrated in **Figures 4 (c)** and **Figure 4 (d)**, as well as **Figure 5 (b)**. A truncated cone is a right circular cone with its top portion removed, resulting in a shape that resembles a cylinder but features ends with different diameters (Buulolo et al., 2024). The *tutup selut* also includes wooden attachments – or "hangers" – on both sides, designed to hold cords when the *selut* and its cover are assembled. The *tutup selut* is smaller in size than the *selut*.

Rope is required during the installation of the *teblok*. It is wrapped around the *teblok* – a technique known as soh – and serves as a substitute for rattan lashing, which is often difficult to source. Furthermore, rope is used in the final assembly stage to secure the various components of the *kiling* (the *teblok*, *kolok*, *selut*, and *tutup*), ensuring they remain firm and do not come apart even when the *kiling* spins rapidly while mounted on its support frame (*panjeran*). Typically, a plastic or nylon cord with a diameter of approximately 2 – 3 mm is used, though the thickness may be increased depending on the size of the *kiling*. The total length of the rope required depends on the number of *soh* (individual lashings) applied around the center of the *kiling*.



(a) (b)

Figure 6. (a) An Odd Number of *Soh* Ties and **(b)** *Soh* Ties Securing a *Teblok* (Researcher's Documentation)

Soh are used to secure the *teblok* to the *kiling* so that it does not shift, as shown in **Figure 6**. The two informants hold differing views regarding the use of *soh* for this purpose *kiling*. I_1 explains that it is customary to use an odd number of *soh* ties (3, 5, 7, etc), as this binding technique is a tradition passed down through generations. On the other hand, I_2 maintains that the soh must be applied symmetrically on both sides, with an equal number of ties used on each side.

P *Kalau tali yang dibuat nge-soh itu bagaimana, pak?*
*(*What if the rope is made *soh*, sir?*)*
I_2 *Satu kiling itu sohnya delapan.*
*(*One *kiling* is like eight*)*
P *Berarti kiri-kanan 4 ya pak?*
*(*That means 4 left and right, sir?*)*

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I_2 *Empat kiri, kanan empat. Ada yang lima, ndak mesti. Tapi yang pasti itu kayaknya empat. Yang bagus itu empat.*
*(*Four left, four right. There are five, not necessarily. But it's definitely like four. The good ones are four.*)*

The difference between I_1 and I_2 arises from variations in the instruction passed down from the previous generation. Devita et al. (2025) support the first perspective, which posits that the *soh* (or rope windings) must be equal in number on both sides of the *teblok* – typically an odd number – since the total count of soh or rope windings on one side of the *teblok* cannot be evenly divided by two.

A *bade kiling* is a wooden slat or board, sized for a *kiling*, featuring a rough surface created by repeatedly hatching it – a process known as *mbacuki* – using a *buding*. A *buding* is a large, distinctive knife used by the Osing people, functioning much like an axe for splitting or cutting wood and bamboo. These tools are employed to craft bade *kiling* – wooden boards approximately two *depa* (about 3 meters) in length – which are fashioned from tree trunks that have been stripped of their bark and thinned down.

Bade *kiling* is made from tree trunks that have been felled, then split and dried in the sun until half dry before being skinned and washed. Wood as a cutting material must be straight and there must be no large branches on the main trunk. The presence of branches on the main trunk will cause the wood fibers to form vortices so that the wood becomes brittle when milled. The diameter of the tree to be milled should not be too large ($\leq$ 150 cm) so that the resulting wood is not too hard and easily breaks or cracks during drying.

After being rough-hewn with an adze, the bade *kiling* must be left to dry. This drying process requires care; the *bade kiling* should not be exposed to excessive heat, but rather kept in a shaded area, such as a veranda. If placed outdoors, it must be kept out of direct, scorching sunlight. Prolonged exposure to intense, direct sun will cause the bade *kiling* to crack or even shatter. The *bade* may be dried further before being put into storage, where it can remain for years before undergoing further processing. If the bade is needed urgently, the timber should be split, rough-hewn an adze, dried in a shaded spot, and then crafted into a *kiling gedhe*. In even more pressing circumstances, the bade can be fashioned into a *kiling gedhe* while still damp, then set upright to dry. However, a *kiling* produced in this manner will inevitably require subsequent repairs, particularly to the *luk* (curvatures) or the arched section on the *lanang* side.

Both informants use a variety of tools – *kaoto*, *kepel*, *lading lanang*, *buding*, *tatah*, and a hammer – to construct a *kiling gedhe*. I_1 also employs a *kintel* (an electronic tool) and a saw to assist in the process. I_2 additionally uses a brush for painting the *kiling*. A *kintel* is an electric planning tool used to level and smooth the surface of the *kiling*, as well as to thin its blades. It functions as an electric planer featuring a rectangular base; however, not all *kiling* makers possess one. The *kintel* used by I_1 has a rectangular base measuring 21×8 cm, with all four corners forming right angles, as shown in **Figure 7 (a)**. This is consistent with the findings of Irsyad et al. (2020), who state that the base of a *kintel* has four sides, where opposite sides are parallel and equal in length, and every corner measures 90°.



(a) (b) (c) (d)

Figure 7. (a) *Kintel*, **(b)** *Kaoto*, **(c)** *Kepel*, and **(d)** *Lading Lanang* (Researcher Documentation)

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A *kaoto* is a manual wood-planing tool – a type of small *kintel* – constructed entirely from iron or steel, as shown in **Figure 7 (b).** It is operated either by gripping both sides with both hands, or by holding the center with one hand while the other hand steadies the kiling (the blade or the component being worked on). The surface of the *kiling* is not flat, even though it is even. The *kaoto* is used to smooth the surface of the kiling on a *tombongan*, as well as to refine the curves on the *pliring* (the beleved edge or slope of the *kiling* blade) or the curvature of a *kiling lanang*.

Figure 7 (c) shows the kepel. A *kepel* is a type of small, manual wooden plane – a handheld woodworking tool – consisting of a small wooden block with a cavity carved into it, fitted with a small steel blade. The *kepel* belonging to I_2 is a block measuring 10 × 7 × 5 cm. This description is supported by Manasikana et al. (2023), who explain that a *kepel* has six sides, with opposing sides being parallel and equal in size. The *kepel* is used to smooth out sharp edges on the sides of a *kiling*, as well as to level and thin the surface of the *kiling* during the process of tuning or adjusting its sound.

The *lading lanang* is a traditional knife unique to the Osing people, characterized by its curved shape and pointed tip, as shown in **Figure 7 (d)**. It is not used for general cooking, but rather specifically for the slaughtering of livestock. The *lading lanang* is emplyoed in the crafting of *tombongan*, *kolok*, and *teblok*, as well as for cutting *soh*. In the absence of a *kintel* or *kaoto*, the *lading lanang* can be used to refine and thin the surface of a *kiling*. *Tatah*, hammers, and saws are used to cut wood or bamboo, and create holes in the center of the *kiling* and *teblok* so that the *selut* and *kolok* components can be fitted into place.

The two informants construct a *kiling* gedhe through a series of processes, which include: crafting the bade *kiling* (main frame/body), *ngintel* (shaping), *ngeluk* (bending), *natah*/*mbolongi* (carving/perforating), and installing the *kolok*, *teblok*, *selut*, and *tutup* (various structural components). Additionally, there is a painting process, which is not performed by I_1. The *bade kiling* is constructed using traditional units of measurement: *depa* and *kilan*. A *depa* is a unit length measured from the fingertips of the right hand to the fingertips of the left hand when the arms are fully extended. A *kilan* is a unit of length measured from the tip of the thumb to the tip of the little finger when the hand is fully stretched out. The actual length of a depa or *kilan* varies from person to person.



(a) (b)

Figure 8. Depa Measurements (a) $\mathbf{I_1}$ and (b) $\mathbf{I_2}$ (Researcher's Documentation)

Figure 8 shows the *depa* measurements I_1 and I_2. The *depa* measurement I_1 can be converted into centimeters, resulting in a length of 156 cm. Meanwhile, the *depa* measurement I_2 can be converted into centimeters, resulting in a length of 161 cm.

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(a) (b)

Figure 9. *Kilan* Measurements (a) $\mathbf{I_1}$ and (b) $\mathbf{I_2}$ (Researcher's Documentation)

Figure 9 illustrates the measurements using *kilan* $\boldsymbol{I_1}$ and $\boldsymbol{I_2}$. The *kilan* measurement of $\boldsymbol{I_1}$ can be converted into a length of 20 cm, while the kilan measurement of $\boldsymbol{I_2}$ can be converted into a length of 22 cm. This indicates that *depa* and *kilan* are non-standard units of length. Rahmawati et al. (2022) expalin that the *depa* and *kilan* are considered non-standard units because their lengths are not always consistent; a *depa* can range from 150 to 180 cm, and a *kilan* can range from 20 to 25 cm. Nevertheless, makers of *kiling* often also employ standard units of measurement. Such conversions are typically performed using a measuring tape or a retractable tape measure, as the *depa* and *kilan* lengths vary from person to person (Zainuddin et al., 2022). The metric length of a *kiling* is usually stated after the owner or maker has specified its dimensions in terms of *depa* and *kilan*.

A *bade* that is being crafted into a *kiling* must be thinned and smoothed using tools called *kintel* or *kaoto*. Additionally, a *kepel* is used to refined more intricate areas. This process is known as *ngintel*. It is generally carried out in stages because the interior of the bade often remains damp. The thickness of the *bade* creates a moisture gradient between its surface and its core; therefore, the *ngintel* process is paused when it reaches the still-damp inner layers, to be resumed once that part has dried further. The purpose of *ngintel* is to balance the weight on both sides of the *kiling*, ensuring it spins smoothly when mounted on its support. Furthermore, *ngintel* is used to shaped the *pliring* (the edges or blades of the *kiling*), which not only allows the device to spin in strong winds but also enables it to produce a clear, resonant sound.

The *ngeluk* process is performed on the *lanang* side to produce sound when it rotates. This is done by heating the *lanang* side – specifically at the point intended for bending – over burning dried coconut leaves. Great care must be taken during this heating process to ensure the *kiling* does not catch fire; should it ignite, the burning area must be immediately extinguished by striking it with leaves or a piece of cloth.



(a) (b)

Figure 10. (a) Clamping Process of a Heated *Kiling* and **(b)** Angle Measurement (Researcher's Documentation)

Next, while still hot, the *kiling* is clamped between two or three living banana three trunks, two large bamboo stalks, or large pipes until it cools, as shown in **Figure 10 (a)**. Once cooled, the *lanang* side of the *kiling* retains the curvature it held while clamped. **Figure 10 (b)** illustrates that the curvature of the *lanang* side reaches an angle of 176^0. This is supported by Fitriani (2022), who notes that the bending of the *lanang* side can result in an angle greater than 90° but less than 180°. Once the desired *luk* (curve)

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is established, the *kiling* may undergo further refinement (*dikintel*) – a process used to adjust its thickness, balance the weight between both sides, or remove any excessive charring caused by the heating process.

The *natah* or *mbolongi* (perforating) process is carried out once the *kiling* has been smoothed down. A hole is bored through the center of the *kiling* to accommodate the *kolok*, *teblok*, and other parts. Created using a *tatah* and hammer, this central opening has a square-shaped cross-section – measuring at least 2×2 cm – which can be enlarge depending on the overall size of the *kiling* being crafted, as shown in **Figure 11**.



(a) (b)

Figure 11. Measurement of a Square-Shaped *Kiling* (Researcher's Documentation)

A *kolok* serves a housing for the *selut* – a component of the *kiling* – and consists of a wooden, tube-like structure with a lid. Constructing a *kolok* requires a small piece of bamboo with a diameter of approximately 3 to 4 cm; the bamboo must be straight and measure about 10 to 15 cm in length. The central bore of the bamboo must have a diameter of 13 to 17 mm. However, the dimensions of the bamboo can be increased to accommodate the specific size of the *kiling's* opening. To craft the *kolok*, the outer surface of the bamboo is shaved down using a lading *lanang* (a type of traditional knife) until it takes on a block-like shape that fits precisely into the *kiling's* opening.

The process of attaching the *teblok* to the *kiling* is carried out using rattan weaving or a circular cord (known as *soh*). Alternatively, this woven cord can be replaced by simply wrapping or tying the component in place. Although it is circular in shape, the *soh* does not maintain a fixed distance from a central point; therefore, it does not form a perfect circle (Ningsih et al., 2019). The *teblok* has the same width as the *kiling* and is positioned parallel to it. It also features a central opening that matches the size and shape of the opening in the *kiling* (Kholisa, 2021). This opening serves as the attachment point for the *kolok*. Both ends of the *teblok* are typically tapered using a lading *lanang*. While it is also possible to cut them using a saw, this method is considered less artistic, according to I_1 i.

The *selut* is attached to one side of the *kolok* – the same side as the *tombongan*. Meanwhile, the *tutup selut* is fitted on the opposite side of the *kolok*, corresponding to the *teblok*. The size of the selut depends on the dimensions of the *kiling* (the overall assembly); a larger *kiling* requires a larger *selut*. The *selut* can be crafted from any type of wood, provided it has a fine grain and good durability. Both the *selut* and *tutup* are secured with multiple wrappings of the same cord used to create the soh, as shown in **Figure 12 (a)**. This ensures that the *selut*, *tutup*, and the other components of the *kiling* remain firmly in place when the structure is set up (*dipanjer*).

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(a) (b)

Figure 12. (a) Installation Process of the *Selut* and **(b)** Painting Process (Researcher's Documentation)

Painting is performed to make the *kiling* more durable and visually. Only I_2 paints the *kiling*, using a black ink mixture – a blend of Chinese ink (*tinta bak*) and varnish, diluted with water, as shown in **Figure 12 (b)**. In contrast, I_1 prefers the *kiling* to retain its natural color, reflecting the materials used. The painting process takes place only after all components of the *kiling* have been crafted and verified for a proper fit. Before painting, the components are typically disassembled to ensure that areas not intended to be painted remain clean; however, I_2 carries out the painting process without disassembling the *kiling*, simply taking care to avoid applying paint to the parts that should remain uncoated. Once a *kiling gedhe* is completed, it is mounted onto its *panjeran* (*dipanjer*). The movement of the *kiling* serves as a tool for determining the cardinal directions.

DISCUSSION

The triangulation results outlined above subsequently serve as the basis for identifying ethnomathematics in the creation of *kiling gedhe*. The findings from this identification are presented in **Table 1**.

Table 1. Ethnomathematics in the Process of Making Kiling Gedhe

Cultural Activity/ Component	Evidence	Mathematical Concept	Mathematical Argumentation	Potential for Learning Connections
Kintel is an electric planer featuring a rectangular base. It is used to level wood – smoothing the surface of *kiling* – and to reduce the thickness of these slats.		Rectangle (2d shape)	The *kintel* base is rectangular, with two pairs of parallel opposite sides and dimensions of 21×8 cm. Each of its four corners measures 90°	As a contextual medium for demonstrating the rectangular shape in mathematics learning during Phase A
Kepel is a manual planer, crafted from a small block of wood that has been hollowed out and fitted with a small steel blade.		Rectangular prism (3D shape)	The *kepel* has dimensions of 10 × 7 × 5 cm.	As a contextual medium for demonstrating the shape of a rectangular prism in mathematics instruction for Phase A and Phase C
The dimensions of *bade* kiling are measured using units of *depa* and *kilan*		Measurement using non-standard units	The conversion of *depa* and *kilan* varies from person to person. One depa is equivalent to 150 to 180 cm,	As a mathematics learning practice, the concept of measurement using non-standard units in Phase A

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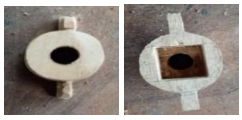
Cultural Activity/ Component	Evidence	Mathematical Concept	Mathematical Argumentation	Potential for Learning Connections
			while one kilan is equivalent to 20 to 25 cm	
Selut is the central component of the kiling that connects the kiling to the panjeran, allowing the kiling to rotate. The selut is tubular in shape.		Cylinder (geometric solid)	The top and bottom surfaces of the selut have the same diameter, namely 8 cm.	As a contextual medium for demonstrating the shape of a cylinder in mathematics learning during Phase D.
The tutup selut is a counterpart to the selut and is shaped like a truncated cone.		Truncate cone (frustum of a cone)	The upper surface of the tutup selut has a diameter of 4 cm, while the lower surface of the tutup selut has diameter of 5 cm.	As a contextual medium for demonstrating the shape of a truncated cone in mathematics learning at the university level
After being heated and clamped, the curves (luk) form an obtuse angle		Obtuse angle	Kiling is no longer straight (180^0) after being heated and clamped; instead, it forms an angle such that $90^0 < \alpha < 180^0$	As a contextual medium for demonstrating obtuse angles in mathematics learning for Phase C
The opening in the center of the tombongan has a square-shaped surface. The depth of the opening is determined solely by specific requirements; therefore, it cannot be describe as resembling a rectangular block or a cube.	 	Square (2D shape)	The surface of the opening in the center of the tombongan is made to measure 2×2 cm	As a contextual medium for demonstrating the rectangular shape in mathematics learning during Phase A

The identification results presented in **Table 1** indicate that the *kiling gedhe* tradition incorporates mathematical concepts, specifically within the domains of geometry and measurement. These findings represent a new contribution to the field of ethnomathematics, focusing on traditional agricultural tools in Indonesia – particularly those from the Banyuwangi region. The potential for educational application suggests that these findings can be integrated into mathematics instruction. In the Banyuwangi area, such integration could strengthen students' mathematical understanding by drawing upon their own local culture. Even outside of Banyuwangi, this integration could broaden students' cultural awareness regarding traditional Indonesian agricultural tools. This is supported by Siswanto et al. (2025), who state that incorporating ethnomathematics into instruction can deepen academic understanding while

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simultaneously reinforcing students' awareness of their cultural identity. Furthermore, using culture as a context for mathematics education can transform abstract mathematical concepts into more concrete, easily understood ideas (Azzahrawani et al., 2025).

The ethnomathematics embedded in the cultural practice of crafting a *kiling gedhe* can be integrated into mathematics instruction, particularly at the primary school level, based on the ethnomathematical elements identified. One example is the introduction of length measurement using traditional units such as *depa* and *kilan*. This concept aligns with the learning objectives for the measurement strand in Phase A (grades 1 and 2). Both units can be applied in practice to meet the learning objective of "measuring and estimating length using non-standard units" (Kemendikdasmen, 2025).

The rectangular shape of the *kintel* base, the square shape of the *tombongan* opening, and the cuboid (rectangular prism) shape of the *kepel* align with the learning objectives for the geometry element in Phase A. These three geometric forms can be used to address the learning objective of "recognizing various 2D shapes (triangles, quadrilaterals, polygons, circles) and 3D shapes (cuboid, cubes, cones, and spheres)" (Kemendikdasmen, 2025). Furthermore, the cuboid shape of the *kepel* can also be utilized to demonstrate the spatial visualization (front, top, and side views) of 3D shapes, as outlined in Phase C.

The ethnomathematics embedded in the cultural practice of constructing a *kiling gedhe* offers an engaging approach for classroom instruction. For instance, students could be tasked with measuring the length of a wall or fence using traditional units – such as the *depa* and *kilan* – and subsequently estimating the actual length in centimeters or meters. Another example involves having students determine the spatial visualization of a rectangular-prism-shaped box. Such activities can be developed into learning modules and instructional media. However, the effectiveness of these materials must be evaluated before they are fully implemented in mathematical lessons. Teachers can prepare these modules and media in advance, then apply them within a *kiling gedhe*-based, culturally contextualized learning framework while simultaneously assessing their effectiveness.

CONCLUSION

This ethnomathematical exploration of the *kiling* in Banyuwangi was conducted on a limited scale with two informants who met the necessary criteria to provide sufficient data. The findings reveal various mathematical concepts embedded within the element of measurement and geometry, including non-standard units of measurement (*depa* and *kilan*), obtuse angles, two-dimensional shapes (squares and rectangles), and three-dimensional geometric solids (rectangular prisms, cylinders, and truncated cones). These results can serve as a foundation for future research, such as implementing these findings into classroom instruction, developing ethnomathematics-based learning media centered on the *kiling*, or other related applications. Further testing is required to evaluate the effectiveness of integrating these research findings into mathematics education

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