Linking Community and Pedagogy: Ethnomodels from Coastal Villages in Panay, Philippines

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ABSTRACT. This design ethnography was conducted in two fishing villages in Panay Island, Philippines. The study aimed to gather data about the mathematical activities of the fisherfolks to identify ethnomodels for the integration of learners' local mathematical knowledge into mathematics instruction. The local mathematical knowledge of the fisherfolks was used as inspiration and grounding for designing and developing a context-based teaching-learning material. Seven key informants were chosen purposively. Participant observation, ethnographic interviews, and elicitation techniques were used for data gathering and triangulation. Furthermore, IDEO's design thinking toolkit for human-centered design was used as a guide for designing and developing the teaching-learning material. The three-part analyses using LeCompte's item, pattern, and structure level analysis revealed that mathematical ideas were embedded in the activities of the fisherfolks and their cultural artifacts. Their mathematical ideas were elaborated in four ethnomodels integrated into the context-based activity book: "The Mathematics of the Fisherfolks".

1.0. Introduction

Why do we have to learn this? is a classic question that mathematics teachers often hear from learners. However, if the learners can see the relationship and interconnectedness of their culture and the formal mathematics that they are learning at school (D'Ambrosio, 2016), they will not only recognize the importance of mathematics (Brandt & Chernoff, 2015) but also learn their own identity. One of the pedagogical approaches used in mathematics that integrates the culture and/or community life of the learners into the mathematics curriculum is ethnomathematics (Shirley, 2015; D'Ambrosio, 2016; Pacio, 2018). Using ethnomathematics principles in the curriculum means using the learner's cultural background (Rosa et al., 2017), local funds of knowledge (Stathopoulou, 2017), and multiple knowledge bases (Turner et al., 2016) to mediate culture and mathematics curriculum.

Ethnomathematics (D'Ambrosio, 2016) promotes the idea that mathematics is an inherent part of human culture, a human activity, and essential in the everyday activities of the people of every cultural group (Orey & Rosa, 2015). It is a field of study that deals with applying mathematical skills, ideas, and procedures by members of specific cultural groups. If ethnomathematics principles are integrated into the mathematics classroom, learners will be able to see the authentic connections between the mathematics they are learning and their community life (Drake et al., 2015). Hence, learners will develop a greater interest in mathematics, and as their interest grows, they will be in a better position to see the importance of learning mathematics (Brandt & Chernoff, 2015). Learners become interested since they learn mathematics in ways they see as relevant to their identities and communities (Barta et al., 2014).

Malapad and Quimbo (2021) argued that lessons connected to learners' prior knowledge and experiences contribute to learning success. Similarly, Brandt and Chernoff (2015) and Turner et al. (2016) recommended that mathematics education should foster a greater understanding of how mathematics is applied in the real world and the communities of the learners. They said that mathematics classrooms need to include the mathematics found in the community that the learners live in. This inclusion of the aspects of ethnomathematics into mathematics instruction helps learners recognize the importance of mathematics to society and daily life (Barta et al., 2014) and the relevance of mathematics as a tool for both problem solving and understanding the world (Bartell et al., (2017).

Indeed, ethnomathematics is a suitable approach for making mathematics lessons culturally appropriate and relevant. However, teachers must have cultural competence in the culture of the learners to be able to use successfully the mathematics found in the community of the learners (Alangui, 2017). Moreover, teachers must know their learners and the communities they live in to develop cultural competence. This means that culturally appropriate and relevant mathematics instruction must start with knowing how mathematics is integrated into the activities of the people in the communities of the learners (Turner et al., 2016; Bartell et al., 2017).

Likewise, designing and developing contextualized teaching-learning material must also start with understanding the culture of the learners. The first step to doing this is research (Bartell et al., 2017)–engage in the community and understand and learn how people mathematize. Then, use the knowledge learned from the community of the learners as inspiration and grounding in designing contextualized teaching-learning materials (Clarke & Clarke, 2011).

The Department of Education (DepEd, 2012) also recognizes the pedagogical impact of contextualizing and making lessons culturally relevant. Thus, it encourages teachers to make the curriculum culture-sensitive and contextualized. However, as of this writing, there is a very limited number of context-based teaching/learning materials made for learners living in coastal communities. Moreover, learning modules given to learners under printed modular distance learning lack or have inadequate activities appropriate to the sociocultural background of the learners (Talimodao & Madrigal, 2021). Hence, this study was conceptualized.

This study aimed to determine the ethnomodels that integrate learners' local mathematical knowledge into the mathematics instruction. These ethnomodels were used as grounding for designing a context-based teaching-learning material. The researcher immersed in two fishing villages located in Panay Island to understand better how fisherfolks mathematize. Understanding how fisherfolks integrate mathematical ideas into their activities was the researcher's first step in developing a culturally-relevant teaching-learning material for learners living in coastal communities.

The results of the study may provide mathematics teachers with information about the ethnomodels of the mathematical ideas of the fisherfolks. They may use these mathematical ideas in contextualizing their lessons. The developed context-based teaching-learning material may also guide teachers in linking learners' community and mathematics instruction.

2.0. Methodology

This study used the theoretical perspective of symbolic interactionism, which is aligned with the epistemological stance of constructionism (Crotty, 1998). Under the epistemological stance of constructionism, meanings are constructed, and the subject and the object emerge as partners in the generation of meanings. Furthermore, symbolic interactionism sees meanings as social products formed through activities of people interacting (Blumer, 1986). Symbolic interactionism is a process of interpretation of actions that exist during social interactions (Lune & Berg, 2017). Thus, immersing in the community of the fisherfolks and interacting with them were needed to understand better how they mathematize. Hence, design ethnography, a methodology that brings together design and ethnography (Clarke & Clarke, 2011), was employed in this study.

Design ethnography incorporates ethnographic techniques–immersion, participant observation, ethnographic interviews, and elicitation techniques–with design science techniques. It uses ethnographic techniques to understand how people live and uses it as insight into the design process (Mohedas, 2016). Brown (2009) termed this aspect of design ethnography as design thinking which means incorporating insights obtained from the fieldwork into the design output. According to Clarke and Clarke (2011), ethnographic techniques in design ethnography increase the researcher's confidence that design ideas will be culturally relevant and more likely to have the desired social impact. Therefore, the researcher used ethnographic methods to gather insights from fisherfolks at two fishing villages and incorporated these insights into the contextualized teaching-learning material. The Innovation Design Engineering Organization's (IDEO, 2015) design thinking toolkit was used as a guide for conducting the design ethnography.

Seven fisherfolks from two coastal villages in Panay Island, Philippines, were selected through purposive sampling. The inclusion criteria were: (a) informant must have broad knowledge about fishing, including making fishing gears; (b) the informant must be a resident of the fishing village for at least ten years, and (c) the informant must be registered as fisherfolk at the Municipal Office of Agriculture.

The data about the mathematical activities of the fisherfolks were gathered from the informants through participant observation, field notes, ethnographic interviews (formal and informal interviews), elicitation and audiovisual techniques, and cultural artifacts. An interview protocol was used during formal interview sessions with the informants. The said interview protocol contained questions based on information that the researcher gathered during the initial survey at the fishing villages.

Interviews were transcribed, open coded, and analyzed using LeCompte's (2000) three levels of analysis—item level, pattern level, and structure level analysis. Likewise, the observation guide accomplished after participant observation, field notes, and cultural artifact data sheet were used to verify, confirm or disconfirm initial items, categories, or patterns identified in the first two levels of analysis. Moreover, cultural artifacts, particularly physical objects, were analyzed by identifying geometrical shapes and patterns.

Data gathering was stopped at data saturation. It was when: (a) the same activities were observed during the visits; (b) no new and interesting topics that could answer the research questions emerged from interviews with the informants; (c) codes from follow up interviews were similar to the codes in the earlier transcripts; and (d) the units/taxonomies or clusters of items, patterns, and structures were clear and complete upon member-checking.

Multiple methods–ethnographic interviews, participant observation, field notes, and cultural artifacts–and multiple data sources were necessary for triangulation. Triangulation techniques increase the accuracy of data gathering (DePoy & Gitlin, 2016). The researcher used this methodological triangulation (Flick, 2018) to verify the consistency and truthfulness of the information gathered. To further ensure the trustworthiness or validity and reliability of the interpretations and findings, the researcher used Lincoln and Guba's (1985) trustworthiness criteria–credibility, transferability, dependability, and confirmability.

In consideration of the ethical conduct of research, a consent form was used to ensure that the informants knew and understood what it meant to participate in this study, so they could decide in a conscious, deliberate way whether they wanted to participate (Mack, 2005) or not. The consent form contained: (a) the purpose of the study; (b) what is expected from the informant if he/she agreed to participate; (c) the fact that their participation is voluntary and they can stop any time they want; and (d) that the personal information gathered from them such as their name should the informant wished not to reveal it will be kept confidential or replaced with a pseudonym of their choice.

3.0. Results and Discussion

Fisherfolks in two coastal villages in Panay Island are excellent navigators and have high directional skills. Their cultural artifacts like *kaba-ong*, *bobo*, *sarap*, and other fishing gears have apparent geometrical concepts, while other daily activities such as measuring, locating, designing, and computing show the application of mathematical ideas. The mathematical ideas of the fisherfolks embedded in their activities and artifacts were elaborated and represented in the form of ethnomodels. An ethnomodel refers to a cultural model that represents mathematical knowledge socially constructed and shared by members of specific cultural groups (Rosa & Orey, 2016a; 2016b). The ethnomodels that were identified from the mathematical activities of the fisherfolks are discussed in the succeeding sections:

Points, line, and plane in *pamirma*

Pamirma is one of the mathematical activities of the fisherfolks involved in navigating. The traditional *pamirma* is a method of marking a location that uses a fisherman's line of sight, stars or constellations, and geographical landmarks to mark a certain location at sea. *Pamirma* is used by fishermen when marking the location of the gill nets that are operated by submerging them underwater overnight. Marking the location of the nets was very important. It allows fisherfolks to easily find their fishing gears, especially when submerged underwater. The mathematical ideas involved in this activity are point, line, plane, collinearity, and intersecting lines (see Figure 1).

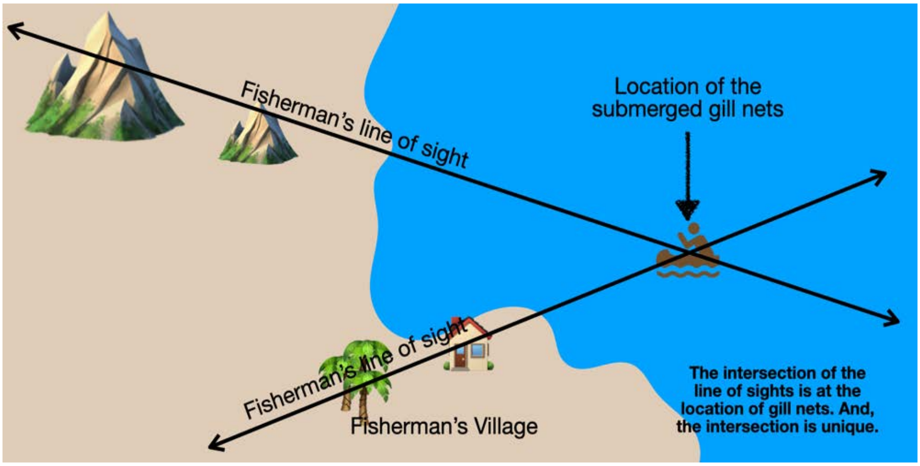

Figure 1

Graphical representation of the pamirma

*Note.*The lines represent the line of sight of the fisherman. The two mountains and the location of the fisherman are collinear. Coconut tree, house, and location of the fisherman are collinear. The lines intersect at the point representing the location of the fisherman. Thus, the location is unique.

An informant, Remie, told how they do the *pamirma*:

> We mark the location [of gill nets] this way. When we are at sea, we can see the mountains of Banate and Anilao. So, we are going to find and mark one shorter mountain and align it with a farther and taller mountain. After which, while on the same spot where the gill nets were submerged, we look toward the direction of our village and see visible landmarks that are aligned. There are houses like that of my mother-in-law whose roofs are visible from there at sea. We are going to align the house to a visible coconut tree or bamboo. We will just follow the alignment of these landmarks, and we will never get lost.

Informant, Marilyn explained:

> For example, they are going to submerge the nets, then do the *pamirma*. They do that before they head home. They will observe their surroundings and look for visible landmarks. The next morning when they return to get their catch, they use these landmarks to locate their nets.

Bishop (1997) classified locating activity as a mathematical practice since it involves exploring one's spatial environment and developing ways to code and symbolize their position within the spatial environment. Fishermen traditionally use their surrounding environments, such as island features, star positions, and landmarks, as an aid in navigating the sea (Sizer, 2000). They pay attention to environmental clues and use them to pinpoint a location and move from location to location (Like et al., 2004).

Algebraic patterns and hexagons in *kaba-ong*

Kaba-ong, a woven basket with hexagonal-hole patterns, is used by local fishermen when drying shrimps. Its purpose is to spread the shrimp evenly onto the surface. Mathematical concepts are evident in the hexagonal designs of the *kaba-ong*. The design is composed of a tessellation of regular hexagons and equilateral triangles (see Figure 2).

Figure 2
Weaving kaba-ong and the base of the woven kaba-ong
*Note.*An informant weaving the *kaba-ong* (left) and the finished *kaba-ong* (right). The base of the kaba-ong is hexagonal; the number of hexagon holes on the side of the base is four and the number of hexagon holes on the diagonal is seven.

Weaving the *kaba-ong* also shows algebraic patterns. The number of bamboo strips needed to make the *kaba-ong* is dependent on its size or the number of hexagon holes on its side. The more hexagonal holes on each side of the base of the *kaba-ong,* the greater the number of bamboo strips needed. Amado, one of the few elders in the village who weaves kaba-ong, said, "to make this [the base of the *kaba-ong*], 24 bamboo strips are needed. Each side of the base will have four [hexagon] holes. Eighteen and 30 bamboo strips can also make the base of the *kaba-ong*."

An excerpt from an observation guide states:

> Amado prepared 24 thin bamboo strips about a half-centimeter wide. He begins by forming seven hexagon-pattern holes (which form the diagonal of the base) using the 18 bamboo strips. Then three bamboo strips are woven on both sides of the seven hexagon patterns until the base of the *kaba-ong* is done with 37 hexagon holes.

Table 1 shows the bamboo strips needed to form the hexagon-shaped base of the *kaba-ong*. To determine the number of bamboo strips needed to build a *kaba-ong* with n number of hexagon holes on each side, multiply n by 6. So, to build a *kaba-ong* with four hexagon holes on each side of the base, the weaver will need twenty-four bamboo strips. Furthermore, the total number of hexagon holes at the base of the *kaba-ong*, as shown in Table 1, forms a quadratic pattern and can be obtained using $3n^2$-3n+1, where n is the number of hexagon holes on each side of the base.

The mathematical ideas used by local fisherfolks in weaving *kaba-ong* substantiate and provide additional knowledge to ethnomathematical studies on weaving conducted locally and in other parts of the world. These studies have shown mathematical ideas embedded in people's woven designs. Symmetry, transformation, geometrical shapes, and arithmetical computations were found to be embedded in woven gappa baskets of Agta people (Cardona, 2015); African baskets, mats, and cloths (Gerdes, 1999); loom-woven Kankana-ey textiles (Baylas et al., 2012); and Bedouin carpets (Katsap & Silverman, 2015). Despite the lack of formal mathematical training, weavers can create different geometrical designs and symmetries (Rubio, 2016).

Table 1. Number of hexagon holes and bamboo strips needed

Number of Hexagon Holes on Each Side of the Base (n)	Number of Bamboo Strips Needed (6n)	Number of Hexagon Holes Along the Diagonal (2n – 1)	Total Number of Hexagon Holes $(3n^2 - 3n + 1)$
5	30	9	61
4	24	7	37
3	18	5	19
2	12	3	7
1	6	1	1

Measurements used by fisherfolks

The measuring activity is one of the obvious mathematical activities of the fisherfolks. They know that they are using mathematics whenever they measure. Bishop (1997) considered measuring as a universal activity present in all cultures. Measuring was concerned with comparing, ordering, and quantifying qualities of value and importance. Qualities like the length of objects, volume, and weight.

Fisherfolks used convenient length measures using their body parts and objects (see Table 2). Fisherfolks use these measures of length when constructing fishing gears and fishing boats. Joel, an informant, emphasized,

> "Usually, the length of the bamboo poles of push nets is three *dupa* (outstretched arms). It is because when the bamboo poles are too short the netting material is narrow and inefficient. It will be hard to operate and you will have less catch."

Another informant, Marilyn, explained,

> "I am measuring this using my *dangaw* (length from outspread thumb to middle finger). So, the distance between these sinkers is two *dangaw*. This is a gill net, it's intended for fish so it requires more sinkers."

On the other hand, the informant, Randy, said, "ah, that is called *sikuan*. Some use that to measure the distances between floaters and sinkers of fishing nets."

The use of body measures is not unique to the fisherfolk culture. It has been used since the invention of mathematics in Ancient Egypt (Burton et al., 2011). Ancient Egyptians used the cubit, a measurement from the elbow to the fingertips, and knotted ropes for measuring fields. Yup'ik culture used body measures when building traditional kayaks (Adams & Lipka, 2019). Whereas Agtas of Sierra Madre used their body parts like *dangan* to measure distances between plants during farming and the length of arrows used for hunting animals (Cardona, 2015).

Table 2. Units of measure for length used by fisherfolks

Units of Measure for Length		
Convenient measures of length using body parts	Convenient measures of length using objects	Units of measure specific to length of nets
Dupa, outstretched arms *Dangaw,* length from outspread thumb to middle-finger *Tuhod,* length from foot to knee *Lawas,* body width *Tapak, foot* *Tikang*, step	*Sikuan,* net needle *Lubid,* rope *Lipak,* dried twigs or stick Length between two marks on a bench or sand	*Paldo* *Mata* *Kihad* *Panyo* *Banata* *Rolyu*

On the other hand, fisherfolks also use dry measures, which include *kaing* or large bamboo basket, *baldi* or bucket, *latex* or bucket but taller than *baldi*, *gantang*, a cubical container made of wood, *leche* or milk can, *caltex*, a 1-liter cylindrical can, *salmon*, a 425-gram can, *banyera* or fish tub, and *kaha* or fish box/container. Fisherfolks use these dry measures to measure the amount or volume of aquatic products they caught.

Measuring activities of the fisherfolks sometimes involved the conversion of units. Randy said, "That is one *paldo*, and that is 18 *dupa*, so approximately 30 meters long." He also explained:

> We measure the *ginamos* or shrimp paste using the *gantangan*, which can contain nine leche of rice. *Gantangan* has been used by our elders here in our community. But, *ginamos* is heavier than rice since a *gantang* of rice is only two and one-fourth kilograms. Whereas, one *gantang* of *ginamos* is three and one-half.

Another informant, Igmedio, said, "one kaha, the box that we use as container for our catch, can contain just around 20 kilograms." He also said, "The *latex*, a bucket taller than a *baldi*, can contain 15 kilograms."

Table 3. Conversion factors used by fisherfolks

Non Standard Unit of Measure	Standard Unit of Measure	Other Conversion Factors
	1 *tapak* = 12 inches	2 *panyo* = 23 *dupa*
	1 *dupa* = 1.5 meters	1 *paldo* = 18 *dupa*
	1 *paldo* = 30 meters	1 *luta* or *banata* = 5 *panyo*
	1 *rayna/gantang* = 3.5 kilograms (*guinamos*)	1 *paldo* = 5 or 6 *kihad*
	1 *rayna/gantang* = 2.25 kilograms (rice)	1 *rolyu* = 6 *panyo*
	1 *kaing* = 70 kilograms	1 *gantang* = 9 *leche* (rice)
	1 *banyera* = 35 kilograms	1 *gantang* = 6 *salmon* (rice)
	1 *kaha* = 25 kilograms	1 *gantang* = 4 *salmon* (shrimp paste)
	1 *latex* = 15 kilograms	
	1 *baldi* = 10 kilograms	

Usually, fisherfolks' conversion activities involved changing units from non-standard units to standard units of measure. The conversion factors used by fisherfolks are shown in Table 3.

Square and Pythagorean theorem in *ariring*

Ariring is a toy windmill made of coconut leaflets. The abundance of coconut trees in the coastal villages and strong winds encourages the people of the village, especially the young children, to play with this toy windmill.

Remie mentioned, "We will cut pieces of coconut leaves, then make it into an *ariring*. My friends and I are running on the shore against the wind while holding the *ariring* we made." Informant Remy recounted, "We played with ariring a lot. Kids who could not make their own *ariring* would take others', which often led to a scuffle. Hahaha."

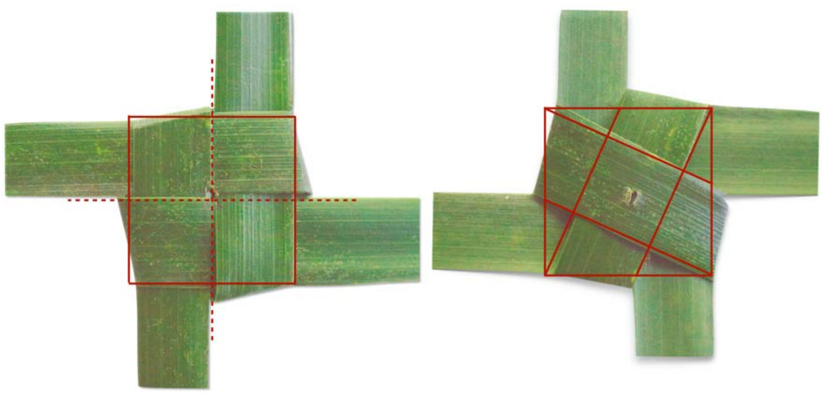

Figure 3

Geometrical pattern on the two sides of the ariring

*Note.*The pattern on one side of the ariring (left) is a square (red solid line). Line of symmetry on the sides of the square (red broken line) intersect at the center of the square. The other side of the ariring (right) shows a square composed of right triangles.

The analysis of the design patterns of *ariring* show inherent mathematical concepts–symmetry, properties of a square, and the Pythagorean theorem. The one side of the *ariring* shows a square pattern divided into four smaller squares of the same sizes (see Figure 3). The lines that divide the square pattern into four equal squares are the two symmetries of the square, and they intersect at the center of the square. This center is a hole on the *ariring* where the stick should be inserted. It is the center of gravity or fulcrum of the *ariring*. Moreover, the other side of the propeller shows a pattern consisting of right triangles and squares. These shapes can fit together to form two smaller squares and can be used to explore the Pythagorean theorem.

A square is a very familiar shape, and, in some cultures, it is a foundation for making other shapes (Pendergrast et al., 2007). In particular, Yup'ik women can form various patterns from shapes derived from a square. Likewise, the square and triangular patterns found from the *ariring* of the fisherfolks and a similar design observed from square-woven buttons in a study by Gerdes (1999) can be fit together to form two smaller squares. Gerdes derived the Pythagorean theorem by showing that the area of the original square is equal to the sum of the areas of the two smaller squares.

The four identified ethnomodels were elaborated and integrated into the four context-based activity modules: (a) *Pamirma*: Explorations into Point, Line, & Plane, (b) *Kaba-ong*: Exploring Quadratic Patterns and Shapes, (c) Measurements in Fishing: Measure, Ratio, and Proportion, and (d) *Ariring*: Explorations into Pythagorean Theorem and Square (see Figure 4). These modules composed the activity book, "Mathematics of the Fisherfolks: Context-based Mathematics Activities for Junior High School Learners".

Figure 4

Context-based activity modules developed using the ethnomodels from coastal villages

Note.Pamirma: Explorations into Point, Line, & Plane (leftmost photo); *Kaba-ong*: Exploring Quadratic Patterns and Shapes (2nd photo from left); Measurements in Fishing: Measure, Ratio and Proportion (3rd photo from left); *Ariring*: Explorations into Pythagorean Theorem and Square (rightmost photo)

5.0. Conclusion

Mathematics is indeed everywhere. Mathematics as a cultural product is present in every culture. Cultural communities, including fishing villages, have their own distinct mathematical knowledge developed and passed on through vicarious and informal learning. Fisherfolks in two fishing villages under study are excellent practitioners of mathematics and expert navigators and geometers, despite a lack of formal mathematics education. Evidence from the interviews, cultural artifacts, observation guides, and contact summary sheets has shown that these fisherfolks apply mathematical concepts embedded in their activities and cultural artifacts. Mathematical ideas are exhibited in navigating or locating, measuring, designing, estimating, and vending activities. In particular, point, line, and plane, collinearity, intersecting lines, units of measure, unit conversion, symmetry, algebraic patterns, geometrical shapes, and Pythagorean theorem manifest in the activities and cultural artifacts of the fisherfolks. The ethnomodels, which are cultural representations of these mathematical ideas, are ideal for linking learners' community and formal mathematics instruction. Mathematics lessons built on these ethnomodels become meaningful and culturally relevant to the learners. It allows learners to see the relevance of mathematics to their everyday life.

The findings of this study show that the community of the learners is a rich resource of mathematical funds of knowledge. It is important, then, that teachers learn about the communities of their learners, especially those who have different sociocultural backgrounds from the teachers. Moreover, the community-based mathematical funds of knowledge of the fisherfolks are important for they are significant and meaningful for the learners living in the coastal villages. Linking learners' community and mathematics classroom through a culturally-relevant pedagogy will help learners see the significance of their education. It will also help develop their confidence, strong sense of self-identity, and pride in their culture and community.

The local knowledge like the weaving of *kaba-ong* and *ariring* must be documented and preserved. Moreover, there is a need to document other local mathematization and indigenous mathematical knowledge as it has been observed that these are slowly vanishing due to technological revolution and enculturation. Moreover, the results reported in this study and developed context-based activity modules may be useful to mathematics teachers, textbook and curriculum writers, and other researchers.

5.0. Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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