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DETERMINING BERNOULLI'S PRINCIPLES IN BASKET WEAVING OF MANOBO TRIBESMEN IN SOUTHERN PHILIPPINES

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ABSTRACT

The indigenous knowledge systems and practices (IKSP) of the *Manobo Dulangan* in *Sultan Kudarat* and the *Erumanen Manuvu* in *Cotabato* Province, primarily in traditional woven crafts, are determined by the author using Bernoulli's Principles. The mathematical concepts of Bernoulli's Principle have always been adapted to each of *Manobos'* fish scooping artisans, with both the results that show that Area one (A_1) is relatively large than Area two (A_2) as ($A_1 >> A_2$) or conversely, directly contributes to the Pressure (P) and Volume (V) of the water (fresh or salt) entering the crafts. As fishing is the primary source of livelihood for the *Manobos* in their different communities, the net force (F_{net}) of the water entering the baskets has some influence on the fish that are caught. Additionally, more fish are caught. Additionally, the primary variables of Bernoulli's Principles also closely connected towards the geometric designs of the woven patterns being used in seafood scooping artisan arts.

Keywords: Ethno physics, cultural tangible heritage, *manobo dulangan, manuvu(manobo) erumanen*, indigenous knowledge system and practices(iksps), bernoulli's principles

INTRODUCTION

Ethno physics has existed a long time ago as proven by the research article of Baquete, Grayson, & Mutimucuio, I.V. (2016) that indigenous knowledge that could be related to physics concepts, from the view of twenty-nine (29) senior citizens from *Chókwé,* a rural village in *Mozambique, East Africa* who volunteered to participate in two sets of in-depth interviews and found out that their indigenous knowledge was useful to them in their daily lives and that these were applications of thermal physics, static electricity and mechanics concepts. Their study also found that in some cases, participants'

explanations were aligned to physics explanations; in some cases, they referred to supernatural phenomena. On the other hand this Indigenous Group from East Africa have this Fish scooping basket called '*xisseka'* used mostly in their livelihood. Silvestre (2000) explained that the traditional Southeast Asian baskets are not only useful to admire their beauty, lovely patinas and interesting forms but it is also necessary to appreciate how they served all aspects of traditional rural life. He emphasized that their importance emerges by examining baskets at the intersection of ethnobotany, or the symbiotic relationship of people and plants, and the role of baskets in supporting traditional agriculture and food production. Further, the humble basket emerges as an elegant expression of the design adage "form follows function".

The most common example of Southeast Asian baskets are coming from Borneo. Sellato (2017) described this fish scoop basket in Borneo as masterpiece of ethno arts, made of rattan and a large burden basket with shoulder straps. This rattan basket has a height of 63 centimeter(cm) and it is used as Fish scooping basket. In the Philippine setting particularly in the Northern Philippine region, Capua(2021) described the presence of ethno physics particularly in ethno-mathematical plane and solid Geometry based on the ethno-mathematical practices of the *Ifugaos'*, from ethno-mathematical practices like festivals and dances, rice farming, musical instruments, ethnic food preparations which are converted into ethno science (ethno physics).

Silvestre (2000) explained that the analysis of basketry can provide high-resolution information on such specific topics as (e.g.. prehistoric) subsistence practices including food procurement, transport, processing and storage, trade and exchange, social status differentiation. regional, cultural, ethnic, and even family or individual "boundaries" that may perforce population movements both in time and through time. Further, there are a few artifacts available to the archaeologists which possess more culturally and idiosyncratically determined, yet, still-visible attributes than does basketwork. On the other hand, whether the basketry is plaited, coiled or twined, it appears to be an established fact that no two populations ever manufactured their basketry in precisely the same fashion.

Finally, not only has this fact been demonstrated ethnographically, but it is archaeologically valid as well. Southern Philippines, particularly in the area of *Sultan Kudarat and Cotabato province*; there a two (2) sub tribes of the *Manobo* clan namely the *Manobo Dulangan* of *Sultan Kudarat* and *Manuvu(Manobo) Erumanen* of *Cotabato* provinces. The study of Arciosa (2021) showed an interaction of the concepts of classical physics in the Indigenous practices of *Manuvu(Manobo) Erumanen* ,particularly, in the field of volume and Newton's law of motion. Further, mostly of Manobo basket weavers don't realize that they are already using the concepts of physical science. The author also found that, aside from the classical mechanics, there is also a fluid mechanics, particularly, the Bernoulli's Principles, applied in the making of basket through the bamboo weaving of the Manobo's clan, specifically in South Central *Mindanao*. Figure 1 (a-d) illustrates the *Manobo's* fish scooping craft arts and at the same time used also as containers when they catch the fishes.

Figures 1.a and 1.b are fish scooping crafts belonging to Manuvu (Manobo*) Erumanen,* while Figures 1.c and 1.d are bamboo crafts made by *Manobo Dulangan*, symmetrically woven and used particularly as fish containers and for scooping. The Sultan Kudarat Manobo Dulangan weavers are all women who specialize in craft arts weaving. On the other hand, these weavers are generally 50 years old or older, and pure native tribesmen existed long ago in this area. Their indigenous skills and practices are legacies of their grandparents. During the focus group discussion (FGD), it was found out that the first container and origin of the concept of baskets are purely the trunk skin of a big tree, as shown in Figure 2.a below.




Figure1.a. The *'Upi'* artisan **Figure 1.b**. The *'Kumu'* artisan **Figure 1.c** The *'Salaf'* artisan **Figure. 1.d**. The *'Kongo'* artisan

Figure 2.a. *Ancestral container of Mano Dulangan tribe*

Figure 2.b. *The Manobo Dulangan weavers with author*

In Figure 2.a. The first basket-a-like made by ancestral grandparents of the *Manobo Dulangan* , called as *'Lihub'* while Figure 2.b. are the *Manobo Dulagan* basket weavers(all women) with their translator(left side) and the author(right side). Due to the abundance of bamboos in their locality, they engaged in basketry weaving to augment their major livelihoods like farming and fishing. The researcher found the pre –historic significance of these different baskets which they made based on their customs and traditions. Before the *Manobo Dulangan* weavers start their basketry weaving , they perform rituals together with their *Datu(Manobo Dulangan* leader) so that everything would be in a good condition and finish the weaving without any problem encountered. The *Manuvu (Manobo) Erumanen* of *North Cotabato* have the same indigenous practices as the *Manobo Dulangan* of *Sultan Kudarat*, as they start their craft arts weaving by performing rituals as well. The *Manuvu(Manobo) Erumanen* are mixed weavers composed of women and men elders with ages ranging between 50 years old and above.

Figure 3.a. *A Manuvu Erumanen weaver performed hand woven*

Figure 3.b. A traditional ritual conducted on every major activity

About the Figure 3.a. *A Manuvu(Manobo) Erumanen* basket weaver, weaving the *'Upi'* craft arts weaving while Figure 3.b. illustrates how they perform rituals in every activity like the validation of the conduct of this research.

REVIEW OF LITERATURE

Basketry/Crafts Arts Weaving

Basket weaving is one of the ethno crafts that has existed since the pre-historic era. This kind of art is dichotomizes the culture of every Indigenous group around the world. The presence of this art in all parts of the world signifies that these indigenous practices are common and still seen in their culture, customs and traditions. Chavez (2019) described in his research that basket weaving started long time ago, during the late nineteenth (19th) century and early twentieth(20th) century by native Americans in the Coastal Southern California. Silvestre (2000), in his ethno archaeological study of basketry hopes to make a substantial contribution to archaeological interpretation, as it is a pioneering perspective on the use of ethno archaeological research. On the other hand, Chavez (2019) that there is ancient artifacts baskets found on Southern *Kalinga*, *Pasil* in the *Cordillera* Mountain Range of *Northern Luzon*, Philippines and signified that basketry weaving is already part of the Filipino culture in the pre-historic era. According to Magulod Jr.,Cortez & Madarang (2017) basket weaving and handicraft making, wild animal hunting, and fishing were considered as the alternative sources of livelihood of the *Agays*, who live in *Cagayan, Northern* Philippines. They still depend on medicinal plants present in their communities to cure their ailments. Further this *Agays* have their indigenous environmental management practices. Pazon & Del Rio (2018) described the main materials used in basket weaving in the Philippines, namely; *buri, boho/bolo, tigok, pandan, nito* and *rattan*. As the researcher found out most of the basket weaving among *Manobos'* use bolo strips, a kind of bamboos found mostly in the tropical forests in the area.

Bernoulli's Principles

Bernoulli's principles is a major sub topic in the fluid mechanics that create difficult concepts among students who take up physics as their major, as well as, the author's problem during his college days. According to Suárez, Zavala& Marti(2017), Bernoulli's equation says that the sum of pressure *P*, the kinetic energy *(KE)* per unit volume *(1/2 pv2*), and the gravitational potential energy *(PEg) per unit volume (PEgy)* has the same value at all points along a streamline. Many students inappropriately use the Bernoulli Equation as a base for their reasoning. This indicates that there is more need to study students' thinking and to develop instructional methods to help students with the Bernoulli Equation. The author tried to connect the concept of Bernoulli's principle to the indigenous knowledge of the *Manobos'* through their basket weaving as main evidence of their indigenous knowledge through their skills and practices in that particular craftsmanship.

METHODS AND DISCUSSION

The main purpose of this study is to preserve this kind of unique indigenous knowledge, systems, and practices (IKSP), particularly in the southern Philippines, where these two (2) major ethno-linguistic groups of *Manobo* clans live peacefully. Furthermore, the author attempts to connect physics concepts, particularly the Bernoulli's principle, to some of Manobo's fish scooping crafts. This fish scooping baskets incorporate Bernoulli's principle in the creation of this one-of-a-kind ethno-craft without

proper training or education in Bernoulli's principle, until the author attempts to integrate culture-based education for physical science. Anthony (2017) stated that science education (ethno physics) should be made more relevant to the perceived needs and interests of the students so that they can engage in skill acquisition programs that are found within the community and that have some cultural significance. The integration of ethno physics into the formal school curriculum will enhance the development of cultural skills such as brandy making, trap making, and so on. The study of ethnophysics helps to reflect the different intellectual traditions of various cultures as well as the scientific problems of each society. Azis and Yulkifli (2021) stated that education based on local culture related to scientific fields also needs to be considered, as it is hoped that the emergence of new knowledge adapted from the local culture and physics learning would lead students towards the desired learning goals. Risdianto et al. (2020) emphasize that an ethnoscience-based direct instruction learning model influences the students' critical thinking skills. In this case, the author attempts to connect the Indigenous Knowledge, Systems, and Practices (IKSPs) of Manobos' fish scooping craft arts and Bernoulli's fluid mechanics principles .Let's start with the four (4) fish scooping baskets of Indigenous groups, namely: *Manobo Dulangan of Sultan Kudarat* and Manuvu (Manobo*) Erumanen of Cotabato* province. The author illustrates the outline view of each basket with the concept of Bernoulli's principle in terms of water flows, areas (A1...An), pressure, and volumes as shown in illustrations 1.0-8.0 and demonstrates how Bernoulli's Principles work in this ethno-craft from ancient Filipino cultures.

Bernoulli's Principle in *Manobo Dulangan* artisans

1. *Salaf a*rtisan used for fish scooping and as container with specifications of a= 5cm ; b= 20 cm and and tiny holes (each diameter = 0.25 cm)

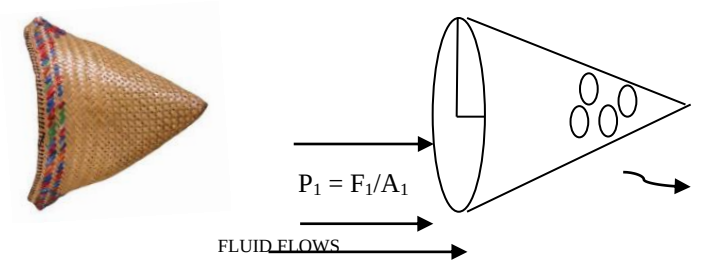

Figure 4. *Physical Appearance of Salaf* Illustration 1.0.Bernoulli's principle in *Salaf*

The *Manobo Dulangan* weaver applies the concepts of Bernoulli's principle in making the *'Salaf'* scooping fish craft arts as shown in Figure 4.0. Illustration 1.0, shows the Bernoulli's principle side of the '*Salaf'* as the Area one A_1(inner hole) should be bigger than any $Area_{(2..n)}$(inner holes), while, the pressure and force are directly proportionate to the areas given in the *'Salaf'*. Everything is in order, so that the catching or scooping of fish is easy to do. To solve the Bernoulli's principle, start in the areas of the *'Salaf'* craft arts, using the formula the area of oblong , Area = a x b x $\prod$ for the bigger hole (A_1) and Area of a tiny circles(n = 18 pcs of tiny holes) at the lower part of the *'Salaf'* craft arts for the second area (A_2). Assuming the water flows with Forces(F_1,F_2) of 100 Newton(N). Let's now solve the Bernoulli's principle using the Pressure formula (P = F/A) behind the making of *'Salaf'* craft arts by the *Manobo Dulangan* weaver.

Let $B = 10\ cm$; $Pressure_1\ (P_1) = Force1(F_1)/Area_1(A_1)$ >> $Pressure_2(P_2) = Force_2(F_2)/Area_2$ (A_2)

$A_1 = (A)(B) \prod = (2.5cm)(10cm) = 78.54\ cm^2$; $A_2 = \prod r^2 = (.0125)^2 \prod = 0.050 cm^2$; a =*2.5cm;* $P_1 = F_1 / A_1 > P_2 = F_2/ A_2$; *100 N/0.008* m^2 > *100N/5 micro meter* ; 12, 500 Pa > P_2 = (6.0 x 10^{-4} Pa) x 18 tiny holes

Therefore P_1 = 12,500 Pascal(Pa) >> P_2 = 0.0108 Pascal (Pa)

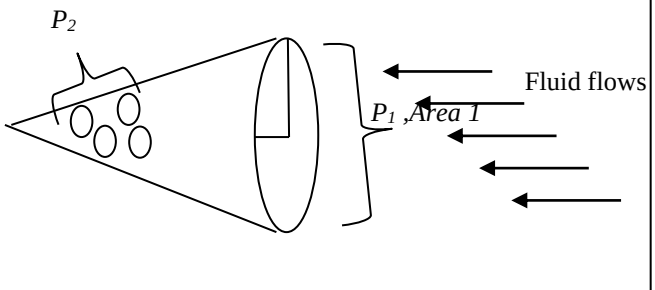

Illustration 2.0. Illustrative drawing with Bernoulli's principle as solution.

Illustration 2.0 proves that there is a Bernoulli's principle behind the *'Salaf'* artisan of the *Manobo Dulangan* in *Sultan Kudarat*. The pressure (P_1) in the big hole ($Area_1$) is directly proportionate to the force and velocity of the water flows. This can catch a fish easily, and the water inside the *'Salaf'* artisan automatically goes out on the *'Salaf'*. The remaining objects are the fish caught by the fishers using this *'Salaf'* artisan.

2. *Kongo artisan* - a fish scooping and container basket with shoulder straps and specification of ; height = 25 cm ; Circular top area = 514 π cm^2 and tiny holes (each diameter = 0.25 cm)

Figure 4.2 .Physical Appearance of *Kongo*

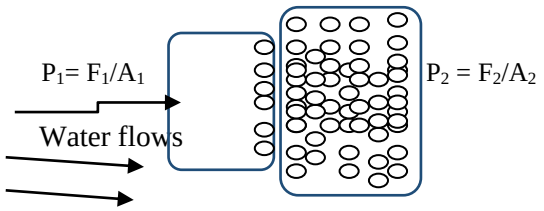

Illustration 3.0.Bernoulli's principle of *Kongo*

This '*Kongo'* artisan is very unique in the sense that it can be used in scooping fish and as container for other kinds of fresh water food like crabs, shrimps and others. Let's solve and find out the Bernoulli's principles behind this '*Kongo'* craft arts weaving of *Manobo Dulangan*.

Let *$Pressure_1$ (P_1) = $Force1(F_1)/Area_1(A_1)$ > $Pressure_2(P_2)$ = $Force_2(F_2/Area_2$* (A_2) ;*A_1 =514* $\prod$ = 1,615 cm^2 ; $A_2 = \prod r^2 = (.0125)^2 \prod = 0.050 cm^2$; *$P_1 = F_1 / A_1$ > P_2 = F_2/ A_2 ; P_1 = 100 N/0.1615 m^2* > P_2 *=100N/5 micro meter ;* P_1 = 12, 500 Pa > P_2 = (6.0 x 10^{-4} Pa) x 300 tiny holes

Therefore $P_1 = 619.20$ *Pascal(Pa)* >> $P_2 = 0.18$ *Pascal (Pa)*

In illustration 4.0 ,where the entry point pressure (A_2) of the water flowing into the '*Kongo'* artisan has a higher pressure, and directly proportionate to the Area and volume compared to the pressure of the water going outside the '*Kongo'* artisan where the pressure is in direct proportion to the tiny holes(A_2), that form part of the weaving design of the '*Kongo'* artisan.

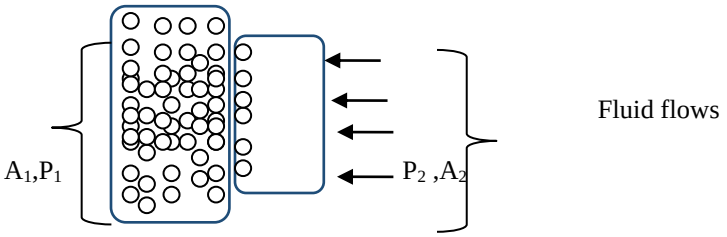

Illustration 4.0. Illustrative Drawing with Bernoulli's principle as solution.

Bernoulli's Principle in the *Manuvu(Manobo) Erumanen* artisans

The *Manuvu(Manobo) Erumanen* of *Cotabato* province have a unique fish scooping artisans as described by its appearance based on their culture and tradition. The materials used in basket weaving are the same as those of *Manobo Dulangan* of *Sultan Kudarat*. The *Manuvu (Manobo) Erumanen* tribe is composed of seven (7) subclans/vansa with their respective ancestral territories, distributed in far-flung areas of major municipalities in *Cotabato* Province and in some parts of *Bukidnon*. The master weavers of *Manuvu (Manobo) Erumanen* are composed of men and women who have unique skills in weaving baskets like the *'Kumu'* and *'Upi'* artisans.

1. *Kumu* artisan - a fish container or scooping basket with shoulder straps and specifications of material as top circular area (radius= 13 cm) ; height of 18cm, tiny holes(radius = 0.125 cm).

Figure 5.0.Physical Appearance of *'Kumu'* artisan

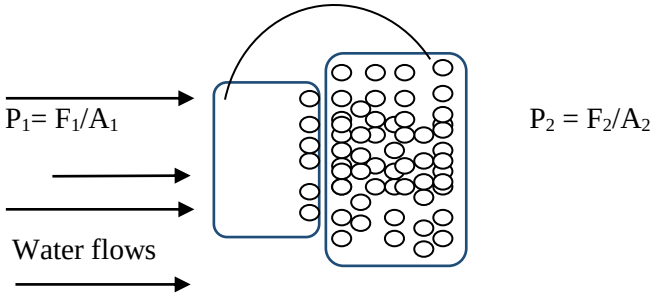

Illustration 5.0.Bernoulli's principle of *'Kumu'* artisan

The Bernoulli's principles behind this '*Kumu'* artisan is through solving the value of Pressure(P_1) of the water getting inside the '*Kumu'* container and the Pressure (P_2) of the water going outside the basket.

Let Pressure1 (P_1) = Force$_1$(F_1)/Area1(A_1) > Pressure2(P_2) =Force2(F_2)/Area2 (A_2) ;

$A_1 = \prod r^2$ = 265.50 cm^2 ; $A_2 = \prod r^2 = (0.14)^2 \prod = 0.060\ cm^2$; $P_1 = F_1 / A_1 > P_2 = F_2 / A_2$; 100 N/0.03 m^2 > 100N/5 micrometer^2 ; 3,333.3 Pa > (6.0 x 10^{-4} Pa) x 400 tiny holes

Therefore P_1 = 3,333.3 Pascal(Pa) >> P_2 = 0.24 Pascal (Pa)

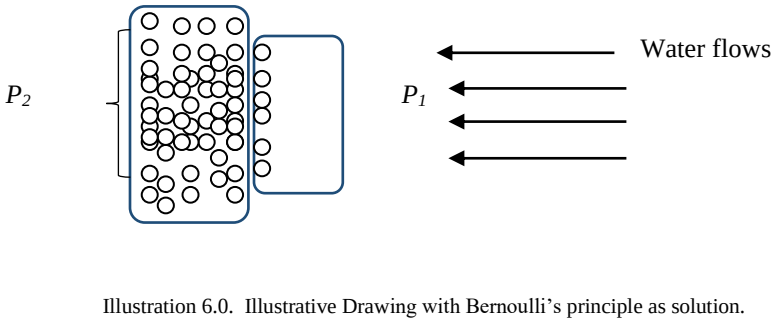

Illustration 6.0. Illustrative Drawing with Bernoulli's principle as solution.

Illustration 6, explains the Bernoulli's principles behind indigenous skills, particularly, in artisans of *Manuvu(Manobo) Erumanen* by calculating the pressure of the water getting inside the basket which main purpose is to catch fish, crabs or shrimps.

2. *Upi* artisan – the most unique among the three(3) scooping baskets and is woven through non-symmetric patterns with additional bamboo stick accessories. The specification of materials are the following ; height is 33 centimeter ; top area -oblong shape (a= 12.5 cm ; b = 14 cm); bottom area-oblong shape (a = 10 cm ; b = 13.5 cm)

Figure 6.0.Physical Appearance of *Upi* artisan

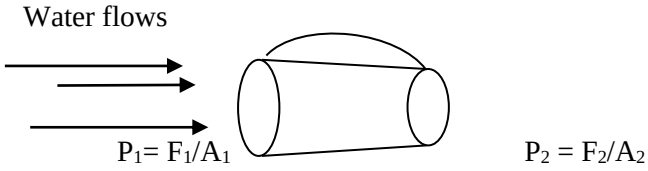

Illustration 7.0.Bernoulli's principle of *Upi* artisan

The author interweaved the indigenous knowledge of *'Upi'* artisan as shown in Figure 6.0 in the science knowedlge particularly in the fluid mechanics in Bernoulli's principle,as illustration 7.0. In solving the value of Pressure as the main variable in the Bernoullli's principle, the author assigned a constant value of Force = 100Newton (N) in response to the water velocity entered the *Upi* area.

Let Pressure$_1$ (P_1) = Force$_1$(F_1)/Area$_1$(A_1) < Pressure$_2$(P_2) =Force$_2$(F_2)/Area$_2$ (A_2) ; A_1 =(a)(b)$\prod$ = (12.5cm)(14cm) $\prod$= 549.80 cm^2 ; A^2 = (a)(b)$\prod$ =(10cm)(13.5cm) =424cm^2 ; $P_1 = F_1 / A_1 < P_2 = F_2 / A_2$; 100 N/0.05 m^2 < 100N/0.04 m^2

Therefore P_1 = 2,000 Pa < P_2 = 2,500 Pa, but still, the water flows through the side Holes(irregular size) of the Upi before getting in the area two(A_2) should be considered.

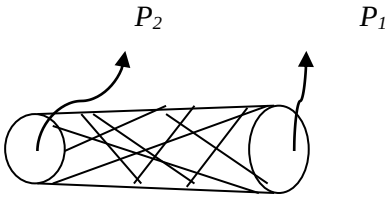

Illustration 8.0. Illustrative Drawing with Bernoulli's principle as solution.

In illustration 8.0, the inner pressure is less than the bottom pressure. The area in between is somewhat closer and the meduim holes in the side walls of the *Pasandalan* basket were also considered.

SUMMARY AND CONCLUSION

Table 1

Summarize the analytical values of Bernoulli's principles with numerical and constant values

The Manobo artisans	P_1	P_2	Results
1. *Salaf* 	P_1 = 12,500 Pascal(Pa)	$P_{2..n}$= 0.0108 Pascal (Pa)	The Kinetic energy(KE) in Pressure1(P_1) is the same in Pressure (P_2) while Potential energy (PE) is constant. P_2 is less than P_1 to trap fish easily.
2. *Kumu* 	P_1 = 619.20 Pascal(Pa)	$P_{2..n}$ = 0.18 Pascal (Pa)	The KE and PE are constants, therefore, Bernoulli's principles can be solved, through Pressure in the two common areas the A_1 and A_2. This basket has tiny holes that represent Area 2 up to Area 100 which vary on the number of holes. A $_{(2..100)}$ is less than A_1. Fishes can easily trap inside the basket and carry more due to a large based volume.

3. Kongo 	P_1 = 3,333.3 Pascal(Pa)	$P_{2..n}$ = 0.24 Pascal (Pa)	Assuming KE and PE are equal to zero(0) in both areas (A1 and A2). Still, the value of areas dominates in explaining Bernoulli's principle. P_2 is thirteen thousand (13,000) times lesser than the P_1 due to the tiny holes all over the area of the artisan.
4.*Upi* 	P_1 = 2,000 Pascal(Pa)	$P_{2..n}$ = 0.48 Pascal (Pa) or $P_{baseArea}$ =2,500(Pa)	The non-symmetrical design artisan is very unique in the sense that the hole designs are in irregular sizes. Assuming the holes are twice (2x) of *Kumu* artisan, then the pressure ($P_{2..n}$) is still smaller compared to the main Pressure (P_1). Before the water flows reach the base area, water flows are already going outside. Easy fishing is being done using this kind of artisan.

Table 1.0 explains Bernoulli's principles behind the making of these different types of *Manobo* artisans. It shows that indigenous knowledge is being transposed onto new knowledge that fits into Philippine science education nowadays. The indigenous knowledge seen in the cultural tangible heritage of the *Manobos*, particularly the *Manobo Dulangan* of *Sultan Kudarat* and the *Manuvu (Manobo) Erumanen* of *Cotabato* Province, is strongly linked with science knowledge, despite the fact that they lack proper pieces of training such as education. Their practices and traditions of basket weaving manifest science-based knowledge as well as their huge indigenous knowledge, which transforms into their unique cultures through crafts and arts.

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