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Ethnomathematics for Capacity Building in Mathematics Education[1]

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The Mathematics Framework for Philippine Basic Education (MATHTED and SEI, in press), a document that aims to guide the development of curricular contents in mathematics, identifies cultural-rootedness as one of the cognitive values that mathematics education in the Philippines must inculcate. Cultural-rootedness is defined as "appreciating the cultural value of mathematics and its origins in many cultures, its rich history and how it has grown and continues to evolve". Ethnomathematics, described as the "mathematics which is practiced among identifiable cultural groups, such as national tribal societies, labor groups, children of a certain age bracket, professional classes and so on" (D'Ambrosio, 1997, p.16), has rich potentials in increasing a country's capacity to provide better mathematics education to its people. It is a vehicle for developing the value of cultural-rootedness thus recognizing and valuing the significant mathematical knowledge within the Philippines and how this mathematics has and continues to play a significant role in building capacity within the Philippines and its people.

This paper provides examples of 'latent' mathematics that are found in various cultural groups in the Philippines. With these examples, the paper argues for changes in Philippine mathematics education to recognize and include Ethnomathematics encouraging teachers and communities to actively seek ways to include the non-traditional, non-Western mathematics in their teaching of mathematics in schools. These would include the different ways of counting, measuring, patterning, navigating, constructing, creating shapes, computing and other mathematical skills

of various cultural groups. By this, Filipino students will learn to both appreciate the many cultures in the country and develop ways to include these cultures into the mainstream Philippine culture, thereby supporting the inclusion of all as being more comprehensively truly a part of the Philippines.

Keywords: *Ethnomathematics, Cultural-Rootedness, Philippine Mathematics Education*

Introduction

I was one of those lucky participants who attended to the dinner sponsored by the Mayor of Puerto Princesa in Palawan on the first night of the International Biennial Conference of the Philippine Council of Mathematics Teacher Educators (MATHTED), Inc. on October 24, 2009. For our entertainment and 'intended learning', a group of local indigenous artists performed dances and song numbers. From the first beat of the traditional drum to the strums of a local "guitar" to the cackling sounds made by the female vocalists, we were all captivated (see Figure 1). This was the indigenous music of the Palaweños or the people of Palawan, known to be "forest people". Their music resembled the movement through the hunting and the bird sounds of the forest. Accompanying the music were the different indigenous dances of Palawan and other tribal groups of the Philippines, showing the various movements that depict the life of the tribes (e.g. harvest season) (see Figure 2). It was an eye-opening experience for me, who grew up in the urban streets of Metro Manila and who only knows pop, disco, and some classical music – all originating from the west – and quite a number of local songs and tunes that include the Kundiman, Pinoy rock, and OPM (i.e. Original Pilipino Music) and, for one, who could only dance the Spanish-inspired courtship folk dances of the Philippines.

Figure 1. Local Singing and Musical Indigenous Artists of Palawan

There was a lot of mathematics that I could identify in the rhythm of the music and sounds as well as in the choreography and count of the dance steps, including the vast array of visual designs and patterns in the costumes worn by the dancers. This was a holistic learning experience with significant "ethnomathematics" appreciation and potential. It was an experience that I treasured because as I reflected on the mathematics that I saw in their music and dance, I began to appreciate the culture of the natives of Palawan, who are very much a part of the Filipino people. It helped me to know myself better as a Filipino!

Cultural-Rootedness as a Value in Philippine Mathematics Education

A main concern in preparing the mathematics framework for Philippine schools was the need to make mathematics relevant to all Filipino students. The framework developers made a conscious effort to include cultural-rootedness as one of six cognitive values that Philippine mathematics education should inculcate among students. Cultural-rootedness means "appreciating the cultural value of mathematics and its origins in many cultures, its rich history and how it has grown and continues to evolve. This

includes the ability of students to recognize that they, as learners of mathematics, can contribute to our nation's funds of knowledge" (MATHTED & SEI, in press). The intent is to demystify mathematics so that Filipinos feel a closer affinity to the subject and learn to appreciate its many uses in the Filipino's national life and culture.

Figure 2. Local Dancers of Palawan

One of the discoveries from the Third International Mathematics and Science Study (TIMSS) in 1995 is that all countries who participated basically follow the same school mathematics curriculum. This is the same mathematics curriculum that is followed by Western countries and Europe. For countries that have been colonized by the West it is often referred to as the colonial mathematics curriculum. To Filipinos, this is the mathematics curriculum introduced to us by the early American educators after Spain ceded the Philippines to the USA. The mathematics that Filipinos studied at the time followed closely what was taught in the USA schools, although not entirely. The mathematics taught was naturally, foreign – it is the mathematics that flourished in Europe and in the United States of America, handed down to us by our then colonial rulers (Vistro-Yu & Pattuinan, 2008). Indeed, any innovation in the USA was likely to be introduced to the Philippines.

The problem with following a curriculum that is a "transplant from the colonial countries" (Atweh, Clarkson, & Nebres, 2003, p.214) is that the contents, including those that appear in textbooks, methods of teaching and subsequent reforms in the curriculum are simply imports and do not take root in the culture of the colonized country. This is because teachers, school leaders and, indeed, the community and students often feel alienated from the principles behind the contents, the methods or the reforms since they are dissociated from the source of all these (Atweh, Clarkson, & Nebres, 2003). The result is inadequate teaching, unsuccessful implementation of reforms, half-baked learning of concepts and skills, and eventually poor achievement in mathematics. These elements add to making mathematics a most unpopular school subject, most hated by students, and most alien to them.

A Historical Perspective

A brief look at the history of mathematics in Philippine schools will show that mathematics is one subject that has had a permanent place in the school curriculum. Moreover, the mathematics that was introduced during the American period before World War 2 was more practical, emphasizing the teaching of skills that were meant to enhance the livelihood of Filipinos. To illustrate, the mathematics textbooks used emphasized arithmetic and its applications to various activities in the country, which included weaving, fishing, lumbering, the rice industry, farming, and accounts (Bonsall & Mercer, 1908; Bonsall, 1906). After World War 2, mathematics was relegated to simply being an academic subject primarily due to the country's emphasis on science as the need for rebuilding the nation became a priority concern. Mathematics was much less useful than science, disconnected from the practical concerns of communities. The New Math movement in the 1960s in the USA spurred the change. The succeeding innovations in the West, particularly in the USA always found their way to the Philippines. Although the Philippines became independent from the USA in 1946, the American influence remained very strong (Vistro-Yu & Pattuinan, 2008).

Making Mathematics a Part of our Culture

With Philippine schools mimicking basically what the American education system supported, the school mathematics curriculum never took root in the Filipino culture. Worse, it has been forgotten that mathematics was once a set of useful skills that contributed to the livelihood of the Filipino people. Furthermore, the Filipino education system often remains ignorant and

unmindful of the mathematics that Filipinos, especially those who live in the peripheries, the mountains, coastal areas, and in other unlikely places, have developed or practice. Hence, there is a need to make mathematics, especially the subject taught in schools, a real part of Filipino education and culture, by recognizing the mathematical activities of peripheral and minority Filipino groups in the curriculum.

Ethnomathematics

Mathematics as a scholarly endeavor has been criticized not only for its disconnection to the real world but also for its role in maintaining the social and economic structure of a society, allowing the elite to manage and rule over the working class (D'Ambrosio, 1997). Ethnomathematics offers a fresh perspective -- that there is mathematics outside of the school curriculum. Ethnomathematics is the mathematics which is practiced among "identifiable cultural groups, such as national tribal societies, labor groups, children of a certain age bracket, professional classes and so on. Its identity depends largely on focuses of interest, on motivation, and on certain codes and jargons, which do not belong to the realm of academic mathematics" (D'Ambrosio, 1997, p.16). Ethnomathematics challenges the universal, canonical mathematics curriculum that is taught in schools and aims for a mathematics that "arises from and is closely related to the experience of mathematics in a given culture" (Nebres, 1988, p. 15).

The thesis of Ethnomathematics is that there are other forms of mathematics that existed among different cultural groups before and beyond the "imported" school or academic mathematics that were transplants from highly industrialized nations to Third World countries (Gerdes, 1996). But, D'Ambrosio warns against confusing ethnomathematics with ethnic mathematics, as it is understood by many (D'Ambrosio & Domite, 2007). To D'Ambrosio, who is the acknowledged 'Father of Ethnomathematics', cultural environments are not limited to ethnic or Indigenous populations but also include "labor and artisan groups and marginalized communities in urban environments, farms and professional groups" (D'Ambrosio & Domite, 2007, p. 202). In order to avoid confusion, D'Ambrosio prefers to use the phrase Program Ethnomathematics to connote a broader perspective of the concept (D'Ambrosio, 1997; Gerdes, 1996; D'Ambrosio & Domite, 2007).

A major construct associated with Ethnomathematics is power or empowerment (D'Ambrosio & Domite, 2007). Recall that Ethnomathematics

offers an enhanced view of what mathematics is. It is a critique of Eurocentric superiority in determining the contents of school mathematics curricula (Powell and Frankenstein, 1997; Rivera and Rossi Becker, 2007). It is by principle a way to recognize the marginalized, the powerless, those often without a political voice and other groups that have been sidelined. By acknowledging the mathematics practiced by these groups, they are essentially being given a role in shaping the education of the people in their country and credit for adding to the richness of the field of mathematics.

The Ethnomathematics approach to curriculum development and the teaching of mathematics has perhaps generated the most controversy (Rivera & Rossi Becker, 2007, p. 215). In terms of curriculum design and instruction, there are four possible roles of Ethnomathematics that have been identified: a replacement for academic mathematics, a supplement to academic mathematics, a springboard for academic mathematic, and a motivation for academic mathematics (Rowlands & Carson, 2002). But, while most supporters insist that Ethnomathematics should not merely provide vignettes of Indigenous mathematical practices or offer ideas for school projects and Bulletin Board posters, few have succeeded in merging ethnomathematics with the dominant academic mathematics to make a real impact on the traditional school curriculum (Rivera & Rossi Becker, 2007). The concept of Ethnomathematics as a field of research, on the other hand, seems to be more acceptable to the mathematics education community. Studies that investigate the mathematics of seamstresses (Hancock, 2001), the language and algorithms used by high school immigrant students in Northern California (Orey, 2003), or the use of a traditional Filipino game as a tool for computations (Manansala, 1995) show the heightened awareness and interest of researchers in uncovering the mathematical practices and alternative mathematics of varying "cultural" groups.

Samples of Filipino Mathematics

Given the numerous ethnic or tribal groups in the Philippines and the various labor, professional, and student age groups, our country is no doubt a fertile ground for Ethnomathematics ideas and research. To date, there are approximately 160 ethnic and tribal groups in the Philippines that include 6 major ethnic groups (Visayan, Tagalog, Ilocano, Bicolano, Kapampangan, and Pangasinense), plus the Moro, Ibanag, Ivatan, and the Sambal, and 9 major tribal groups (B'laan, Bontocs, Ibaloi, Lumad, Mangyan, Maranao, Negrito, Tagbanua, and Tausug) (www.buzzle.com/articles/list-of-different-ethnic-groups-in-the-

philippines.html). Clearly, if one were to document the mathematical activities of each of these groups, one would have a thick book of resource for Filipino students. In addition, one can note the mathematics practiced by *Jeepney* and *tricycle* drivers, the *Sari-sari* store owners, the street food vendors (e.g. *Magtataho*, *balut* vendor, and the *sorbetero*), who are undoubtedly part of the Filipino way of life.

Filipino Mathematics from Research

Manansala (1995) studied the mathematical usages of the Sungka Board, which is used in a sedentary game for two players that entails filling up one's own large well with cowrie shells distributed among 7 smaller wells on each side of the board (see Figure 3). Each small well initially contains 7 cowrie shells. The two players begin at the same time with each taking all the shells from one small well on their side of the board and in a clockwise direction, dropping one cowrie shell in each of the wells including one's large well at a time, picking up the shells in the well where the last shell is dropped and continuing until an empty well is reached. The game itself is rich in mathematics. One can study the many counting techniques that may be employed to ensure a longer playing time and eventually, a huge collection of cowrie shells at the end of the game.

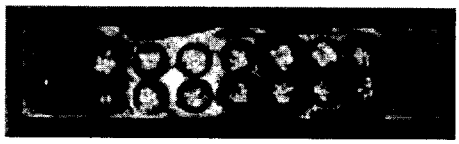

Figure 3. Philippine Sungka Board
(www.takdangaralin.com/philippine-game-sungka/)

Manasala's study however, took an unusual bent. He studied how the sungka board can be used to facilitate numerical computations that resemble the paper-and-pencil way of adding, subtracting, multiplying and dividing numbers vertically. What is interesting is that he used the numeration system of Ifugaos (people in the uplands of Northern Philippines) that used factors of 2.5, 5, and 10 to illustrate the method of computation using the sungka board. He argues that the sungka board is known to some tribal Filipinos and could be considered a computational tool in the same vein as the abacus among the Chinese. The wells in the sungka board each

represent a place value, allowing for Ifugaos to compute large numbers without using too many objects. The tool and computational method facilitate the learning of abstract quantities, which the Ifugaos would not learn if they merely use discrete objects.

Mathematicians from the University of the Philippines—Baguio have studied successfully the algebra of the weaving patterns, gong music, and kinship system of the Kankana-ey of the Mountain Province in the Philippines (UP Baguio, 1996). Of special interest to many is the woven fabric designs made by tribal Filipinos. The UP Baguio team identified all the derived patterns from the woven fabrics of the Kankana-ey, used as a skirt (*tapis*), blanket (*ules*), women's waistband (*bakget*), and men's loincloth (*wanes*). Twenty-eight different patterns were identified, which are formed by the repetition of some design or motif either vertically or horizontally. The 28 patterns were classified according to the seven frieze group structures. The UP team realized that the Kankana-ey strip patterns use four of the seven frieze group structures. The four frieze patterns are

F_1^1 (reflection a about a line l and translation t),

F_1^2 (two reflections a and b about lines l_1 and l_2, respectively),

F_2^1 (three reflections a, b, and c about lines l_1, l_2, and l_3), and

F_2^2 (reflection a about a line l and half-turn about A)

(UP Baguio, 1996 p. 25 & 116).

Figure 4 shows an F_2^1 pattern on a Kankana-ey woman's skirt.

Reminiscent of the study by Carraher, Carraher and Schliemann (1985) of the Brazilian street children and the mathematics that they practice is Belisario's (1995) study that investigated vending practices of children of vendor families in Zamboanga City, Philippines. She found some interesting computational techniques that these children use which do not conform to the techniques taught in schools, though they are correct, efficient and effective.

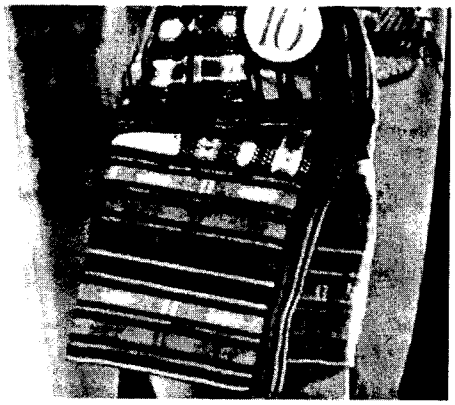

Figure 4. A Kankana-ey woman's skirt
saluyot.wordpress.com/2008/11/page/2/

Informal Filipino Mathematics

The mathematical activities of other groups, though not thoroughly documented, are worth studying. For example, one wonders about the computational, spatial, and visual skills of *Jeepney* drivers in the Philippines as they go through their designated route picking up passengers from random points, keeping track of who has paid how much, while weaving in and out of the roads through heavy traffic. Much of the successful collection of the fare is due to trust between and among the passengers and the *Jeepney* driver. However, without a doubt a certain amount of mathematical skills must be involved.

The *Sari-Sari* store (small retail stores) has become a huge part of Philippine culture. They are often found inside gated residential villages and small towns. These stores sell staple products such as sugar, salt, and oil that may have been repacked in smaller amounts or quantities or personal items that are packed in smaller containers like shampoos in sachets, and snack food in smaller bags. Naturally, the prices of goods sold here are higher than in the city supermarkets. However, one thing going for these small stores is that they are able to extend credit to their customers while large supermarkets do not. The "economics of the *Sari-Sari* store" and the mathematical activity that occurs as customers buy and pay and store owners allow for credit to customers who cannot pay immediately can be very interesting, There is a constant negotiation between store owners and customers -- "Please put it on credit. I don't have cash right now." or

"When will you ever pay me?" -- and the exchange of money can happen quite fast. Reasoning and logic on top of numerical skills are necessary for store owners to survive in these economic transactions.

Ethnomathematics for National Capacity Building

The examples given in the earlier section show that Filipino culture is potentially rich in mathematics. A deeper understanding of our culture can definitely help in identifying and developing other mathematics and mathematical activities that varying groups of Filipinos practice or will continue to need into the future. This would make mathematics more relevant, connected and useful to our people. The role of Ethnomathematics in capacity building is important because Ethnomathematics empowers and can bring about genuine integration and relevance. Revisions and reforms in curricula, pedagogy, assessment, materials development, and teacher education should follow.

With Ethnomathematics, one can expect that:

1) Filipino Mathematics teachers will feel more inspired and engaged in curriculum development by including a variety of culturally relevant mathematical contexts, situations, and problems in their mathematics lessons;
2) Filipino pupils will be excited to be able to contribute their own experiences and culture to help shape and enrich the learning in mathematics lessons;
3) Filipino mathematics teachers and pupils will feel proud of their own heritage and culture;
4) The Philippines will contribute to further developments and understandings in the field of mathematics through research, and;
5) Filipino mathematics teachers will gain better understanding of mathematics and personal competence in teaching mathematics.

More concretely, recall that with the transplanted curriculum from the colonial masters, any reform and innovation will be difficult to implement. If the mathematics from different cultural groups in the Philippines were to genuinely become part of the school curriculum, teachers would have better success in implementing reforms since the curriculum has become "Filipinized". Hopefully, pupils will understand better, learn more, and achieve higher levels of knowledge and competence.

Future Directions

While we hope to enjoy new and old discoveries of mathematical ideas and processes found among different cultural groups, it is important to note that one goal that must be maintained is to make sure that these cultural groups do benefit from advanced knowledge in the different branches of mathematics as well as from advancements in technologies. Ethnomathematics is a way of strengthening identity and building capacity within one's self of being Filipino whilst achieving the knowledge and enhanced mathematics learning required to take one's place purposefully as a citizen within the local, national and global community. It would be very sad for example that while we enjoy learning about the different musical patterns in the songs and drum beats of Palaweños, there is nothing new that they have learnt. What would be good is for them to expand their music and include new counts and drum beats using numbers and numerical patterns, to create new music and songs. In other words, we educators should ensure that through ethnomathematics people are given the educational opportunities to learn better mathematical ideas and methods so they may enhance their lives and personal well-being as well.

Baroro (1999), in her study of Philippine art designs on fabric, dress ornaments, and containers of different ethnic groups, found the preference for translations, vertical reflections or combinations of translations, vertical and horizontal reflections in creating design patterns. As well, there is some notable preference for translations and half-turns. In my personal conversation with her, she revealed her fervent wish for more varied pattern designs in Philippine art. It would benefit our ethnic brothers and sisters to learn to create more varied and complex designs which would enrich their art and culture.

The UP Baguio Team should replicate their work with the Kankana-ey tribe. What is remarkable about the UP study (1996) is that in addition to uncovering and analyzing the mathematics in the Kankana-ey culture, sample lesson guides were written to exemplify how ethnomathematics can become truly a part of the school curriculum. This pioneering effort is laudable and must become a shining example for all mathematics teachers. This implies that Ethnomathematics has a further role in mathematics teacher education. Ethnomathematics must not only influence school mathematics curriculum design; it must also influence the education of future Filipino mathematics teachers. Future mathematics teachers and researchers need to gain first-hand experience in the uncovering and

documentation of mathematical activities of the different cultural groups in order to be able to write genuine reform lessons in mathematics.

Ethnomathematics has a place in Philippine school mathematics. Ethnomathematics has a role in building our nation's strength and capacity in providing better quality mathematics education to all Filipino students.

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